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Ceramic Abstracts and the Bulletin

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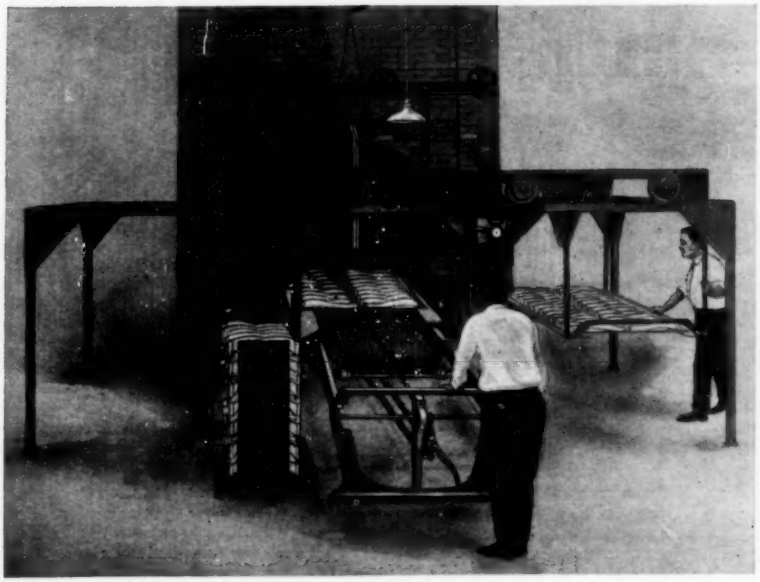

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ORIGINAL PAPERS

THE RELATIVE MAGNITUDE OF RADIATION AND CONVECTION HEATING IN A MUFFLE KILN[1]

BY J. T. LITTLETON, JR.

ABSTRACT

Rates of Heating by Convection and by Radiation in a Muffle Kiln, 38″ x 18″ x 36″ high, were each determined for temperatures from 350° to 800°C from measurements with a steady flow water calorimeter whose surface was first gold plated and then covered with a mixture of platinum black and lamp black. Taking the reflecting powers as 91 and 4 per cent, respectively, for the two surfaces, the radiation heating increases approximately according to the Stefan-Boltzmann fourth power law, while the convection heating comes out proportional to the temperature difference between calorimeter and muffle; that is, $C = \gamma(T-t)$ where $\gamma = 2.34 \times 10^{-4}$ gm. cal./cm.^{2} sec. The ratio of convection to radiation decreases from about .40 at 350° to .10 at 800°C, so that for the higher temperatures the convection heating may be neglected in rough computations of the rate of heating in such a kiln.

Introduction

The rate of radiation absorption by a body of known temperature in an enclosed space having walls at a known constant temperature can be easily computed by the Stefan-Boltzmann formula but this heating rate is only a part of the whole. The heat received from the surrounding gases which is called convection heating will evidently depend upon the freedom of circulation of gas about the body considered and since it has not been thoroughly studied has not been subject to computation. Due

[1] Presented before the Glass Division, Pittsburgh Meeting, February, 1923.

to the lack of knowledge of this factor, very little attempt has been made to compute heating rates.

Cooling by convection and radiation has been studied by Langmuir[1] on surfaces disposed in a certain definite way. His observations show that radiation cooling is very much greater than convection cooling. However, there seems to be a somewhat general belief, among operating engineers at any rate, that radiation heating may be neglected in comparison with convection heating. The results of this paper on heating confirm Langmuir's conclusions on cooling and indicate that in all cases except where flames are playing directly upon the body radiation heating is much the more important factor of the two and for very high temperatures convection heating can be neglected with probably no more than a 10% error

Theory

The Stefan-Boltzmann law is

$$J = \sigma(T^4 - t^4) \tag{1}$$

where J is the total energy absorbed per cm.^{2} per sec. by a black body at absolute temperature t^0 from another black body at absolute temperature T^0 and σ is 1.277×10^{-12} gram calories. If the body at temperature t is not a black body but has a reflecting surface, J will be decreased by the amount of the reflection. If the reflection be .90, J will have a value only one-tenth of that of the black body surface.

The convection heating may be assumed to be proportional to the difference of temperature between the body and the gas. This may be written as

$$C = \gamma(T - t) \tag{2}$$

where C is the total convected energy per cm.^{2} received by a body at absolute temperature T from a surrounding gas at temperature t, and γ is the constant applicable to the particular configuration. C does not depend upon the optical condition of the surface but is the same for a reflecting surface as for a black surface if they are otherwise identical.

Let Q be the total quantity of heat per cm.^{2} per sec. received by the body, then

$$Q = RJ + C \tag{3}$$

where R is the reflecting power of the surface. Since C does not depend upon the optical condition of the surface it may be eliminated by a simultaneous solution of the two equations for the body having two known reflectivities as

$$Q_1 = R_1 J + C \tag{4}$$

$$Q_2 = R_2 J + C \tag{5}$$

$$Q_1 - Q_2 = J(R_1 - R_2) \tag{6}$$

[1] *Trans. Am. Electro-Chem. Soc.*, **22**, 299 (1913).

Hence J is determined in this case by measuring Q_1 and Q_2 or by measuring the comparative rates of heating of the same body under the same identical conditions except for the reflecting power. C may then be immediately obtained, and substitution of this value in equation 2 gives γ, and if γ is known, the total quantity of heat Q, in equation 3, may be computed for any desired temperature and temperature difference.

Experimental Method

The heating chamber investigated was a Drakenfeld muffle kiln approximately 38 inches long, 18 inches wide and 36 inches high. Accordingly this work only applies to muffle heating.

Since it is necessary to make measurements on a body with its surface having two different reflecting powers, it is evident that the greater the difference in these two reflecting powers the more accurate will be the measurements. Accordingly a surface covered with a mixture of platinum black and lamp black having a reflecting power, according to Coblentz, of 2% was compared to the same surface cleaned and gold plated. The reflecting power of the gold surface was assumed to be 91%. This value is of the same order of magnitude as the value given in the tables but the basis for assuming just 91% as the reflecting power constant will be given later. Since the blackened surface showed a few scattered pits and smears the reflecting power of 4% instead of 2% as given by Coblentz was assumed as being probably more nearly correct.

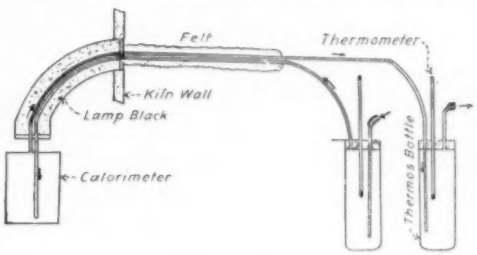

FIG. 1.

A copper calorimeter approximately 10.6 cm. high, 9 cm. in diameter, 427.4 cm. in area and 0.75 mm. thick was used as the body for which the rate of heating was to be determined. The apparatus shown in Fig. 1 illustrates a simple calorimetric scheme for measuring this rate. Water from a tap was run through a one quart thermos bottle in which a thermometer graduated to one hundredth of a degree centigrade was immersed. The water flowed from a thermos bottle through a $^1/_4$-inch brass tube into the calorimeter and out into a second thermos bottle. The rate of flow of the water was adjusted so that the temperature of the calorimeter did not rise more than 15°C in the maximum case. The rate of flow of the water was measured by a stop watch and a 1000-cc. graduated flask. Hence the total quantity of heat Q in gram calories absorbed by the calorimeter is the flow of water per second through the calorimeter times the change in temperature of the water measured in centigrade degrees.

The furnace temperature was determined by means of six iron-constantan thermocouples placed one couple at the center of each wall. An average of the six thermocouple readings was taken as the average wall temperature. There is undoubtedly some difference between the thermocouple readings and the wall temperature in a case of this kind but for the purpose of this experiment this method was considered as sufficiently exact. The temperature readings of the different couples with the exception of the one in the front wall which was lower than the others by about 10%, did not vary among themselves more than 10°C. The furnace was allowed to attain a constant temperature before a calorimetric measurement was made.

To determine the correction for the heat gained through the connecting tube, a blank run was made with a brass tube entirely insulated like the tube shown in Fig. 1, but instead of leading to the calorimeter the tube used had a U-bend in the bottom, this being also insulated. The rate of heating for this tube was determined for different temperatures in the furnace up to 800°C. The curve thus obtained between this rate of heating and the temperature of the kiln was used as a correction in the other experiments so as to eliminate all heating except that of the calorimeter. The blackened calorimeter was then put in place and the rate of heat absorption at different temperatures determined.

The temperature of the external surface of the calorimeter was assumed to be that of the outgoing water since the total quantity of heat absorbed by the calorimeter was not sufficient to introduce a temperature gradient through the calorimeter wall of anything like 1°C. The actual temperature varied from 15°C to 30°C depending upon the rate of heat absorption. Computation proves that when T is large, errors in measurement of t are relatively unimportant as regards radiation heating.

The procedure was slightly different in the case of the gold plated calorimeter. In this case there was a noticeable tendency for water vapor to condense on the calorimeter giving a film of water as a reflecting surface instead of the gold. Since water has a fairly high absorption coefficient for the existing radiations the results under these conditions were unreliable. Accordingly the furnace was heated above the maximum temperature desired with all the apparatus in place, and then the door was opened and the calorimeter quickly dried off and polished. The observations accordingly were taken with the kiln cooling instead of at a constant temperature. However the rate of cooling was so slow that the temperature did not change more than 1°C during a measurement. Under identical conditions a test made on the black calorimeter showed the same rate of heating with the flames off as with the flames burning proving that the presence of flames in the muffle did not affect convection inside of the kiln.

In this manner the total quantities of heat absorbed by the calorimeter under identical conditions except for having two largely different reflecting surfaces were obtained. These results are shown in the curves in Fig. 2.

The values of J at any desired temperature follow immediately by a substitution in equation 6 of the values of Q_1 and Q_2 obtained from the curves. Having thus determined J, C follows at once from equations 4 or 5. By a cut and try method it was determined that the assumed value of 91% of the reflection coefficient of the gold plated surface gave a straight line for the curve between the temperature and convection heating. The radiation heating and convection heating curves as obtained in this manner are plotted in Fig. 3. The radiation curve computed for the Stefan-Boltzmann formula is plotted for purposes of comparison. While this curve does not coincide exactly with the curve as measured, the difference between the two can be accounted for if the thermocouples do not give the actual wall temperatures. Furthermore the colder wall of the kiln subtended a greater angular section of the calorimeter as it was nearer this wall and the wall heated directly one side and not the bottom. The fact that the average temperature was taken instead of the 4th root of the mean of the 4th power temperatures introduces a slight error. The convection heating curve passes through the origin of the coördinates as it should according to the assumed equation.

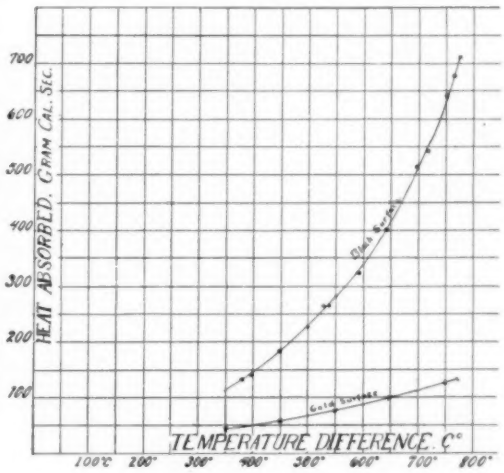

FIG. 2.

Since the area of this calorimeter was 427.4 cm.^{2} the value of γ or the convection constant is obtained by dividing the slope of the curve by the area of the calorimeter and it comes out for this case 2.34×10^{-4} gram cal. per sec. per cm.^{2}

It is evident from the radiation curve that the rate of heating does not depend so largely upon the value of the temperature of the cold surface or the temperature difference between the cold surface and the hot body as it does upon the absolute value of the temperature of the hot body.

At the maximum temperature of 775°C difference obtained it is evident that the radiation is about nine times as great as the convection heating. For a case where T is 1327°C or 1600°Å and t is 0°C or 273°Å, radia-

tion heating is 27 times convection heating. It is for this reason that for practical purposes where the temperatures are high the error would not be very large if convection heating were entirely neglected. However, if a higher degree of accuracy were desired a substitution of the above value of γ in equation 3 would give an approximate correction term to take care of the convection heating even though this value of γ would not apply exactly to the configuration used.

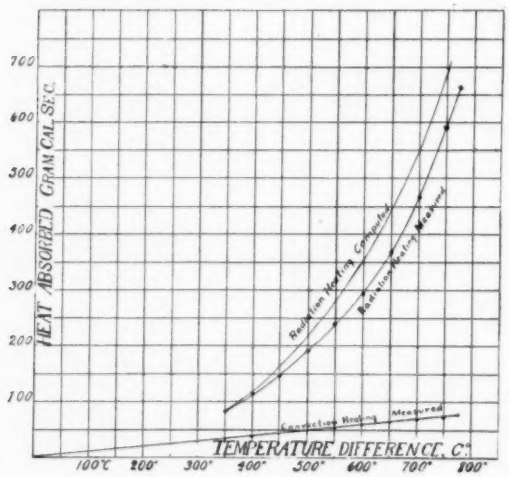

FIG. 3.

The proper consideration of the relative values of these two types of heating should be of considerable assistance in designing kilns, leers, and some types of furnaces and in the disposition of the ware within them so as to obtain the most uniform and efficient heating. By means of these constants, that is the radiation and convection constant, and the proper application of the ordinary equations of thermal conductivity, the heating curves and the temperature gradients existing during heating may be computed.

Summary

1. The absolute amounts of radiation and convection heating occurring in a muffle kiln of a certain type have been determined for temperatures from 350° to 800°C.

2. The convection heating is expressed in the form of $C = \gamma(T - t)$. The convection constant γ is found to be 2.34×10^{-4} gram cal. per sec. per cm.^{2}

3. The radiation heating as measured checked with reasonable accuracy that computed by the Stefan-Boltzmann formula.

4. It has been proved that for high temperatures the radiation heating is so much greater than the convection heating that unless a high degree of accuracy is desired the convection heating may be neglected.

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SIMPLE METHOD OF MEASURING COLOR

By A. E. O. Munsell

ABSTRACT

Clear thinking on color is important. The Munsell System clarifies; shows color in three dimensions: hue, value, chroma. The method of measuring color on solid, sphere, irregular solid, vertical and horizontal slices through the solid. Method of notation. Summary.

It may be taken for granted that the faculty of clear thinking in the realm of color and the ability to analyze and apply color in the industrial world are of utmost importance.

The vital questions for anyone working in color are these: How shall color be freed from a fog of words and placed in a clear light? How may we define our color images, produce our color harmonies, record our results, and write all these in a complete and measured system?

In general, colors lack definiteness. Like ghosts they drift in and out of our consciousness and are effaced by the next new impression unless we form a mental habit of correlating colors by some fixed method.

The Munsell System offers such a method. To the uninitiated it may seem complicated, but in reality it is a simple method applied to clear thinking in the realm of color. This clear thinking becomes perfectly possible when we recognize the fact that each particular color has three dimensions of hue, value and chroma.

Let us consider each of these dimensions separately.

What Is Hue?—It is that quality which distinguishes a red from a yellow, or a green from a blue or red-purple. We look at a daffodil and say, "Why, yes! That is yellow. Yellow is the hue." We say that the hue of the ocean is blue and the hue of the wagon is red. The ribbons on the baby's bonnet are blue, but they are not at all the color of the deep sea blue. A brick may be red, but not at all like the vermilion of the fire wagon. So we must seek some other qualities to define more completely the color we have in mind.

What Is Value?—The blue on the bonnet was light, while that of the ocean was very dark. There we have another measurable quality of color. Is it light or dark? How light or how dark is it? *This is its value.* A maroon is a dark red (low in value), and pink is light red (high in value), yet they both belong to the same family of red.

What Is Chroma?—The red of the maroon coat, or the brick, or the pink ribbon is not at all like the strong red we see in the fire wagon. There, then, is another distinction. The weather-worn brick is very gray compared to the strong red. There is a quality by which we distinguish such a strong color from a weak one. *This is called chroma.* To say a poster is strong in color gives no idea as to its values or hues, but merely its chroma. A circus poster has strong color: a strong red, a strong yellow, and strong

blue. A catalog cover for fine stationery might have red, yellow and blue, but the chroma would be weak in order to give it a more reserved and refined appearance.

But how are all these measured? Very easily and very definitely.

Let us think of color in the form of a solid sphere like the world shown on the geography globe. Imagine that this sphere has an axis running from

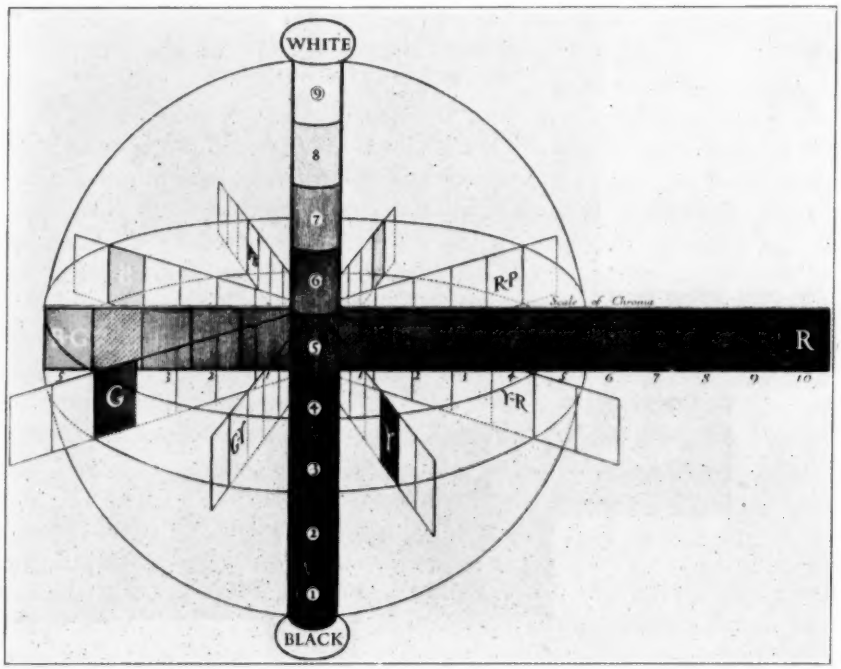


FIG. 1.—Visualizing the three dimensions in graphic form. The dimension of hue is expressed by a word or the initial letters of the word—green, yellow-red, etc., or G, Y-R. The dimension of *value* is expressed by the number of the step upon the Value scale, written over a line thus—5/. The dimension of *chroma* is expressed by the number of the step on the Chroma scale, written below the line thus—/5. For example, the color at the extreme right of the diagram is Red, Value 5, Chroma 10, and is expressed as R 5/10.

the north to the south pole. The bottom of the globe, or the south pole, is black, and the top, or north pole, is white. The axis within is graded from black to white through a number of equal steps. Let us think of it as ten steps from black, 0, to white, 10. Half way up the axis we find a gray, 5, midway between white and black. Above are lighter grays, and below, darker grays. But these are merely grays, with no hint of any hue—simply gradations between black and white. This is our *value scale*, and

by it we may measure any value and be able to tell whether the blue ribbon is nearer white, and the deep blue sea nearer black, or just where in the scale each belongs.

Around the globe imagine a band drawn at the equator. If this band is divided into five equal sections around the globe and each section painted with red, yellow, green, blue and purple, respectively, we have what may be called the hue circuit of five principal hues. We may divide the circuit into ten hues, the principal and intermediate colors: red, yellow-red, yellow, green-yellow, green, blue-green, blue, purple-blue, purple, and red-purple, back to red.

We often find colors which do not exactly correspond to one of these ten principal hues but which lie somewhere between two of them. For the purpose of more accurately placing these colors we may further subdivide each of the ten hues into ten smaller portions, thus creating one hundred divisions in our hue circuit.

As this particular circuit lies on the equator we know it is half way between the black of the south pole and the white of the north pole. Therefore these colors are all of middle value, 5/, none lighter and none darker then any of the others in the circuit.

Where, then, are the lighter and darker colors placed? They are placed above the equator if they are lighter, and below if they are darker. Imagine a series of bands about the globe above and below the equator like the zones of the earth. Above, toward the north pole are the rings, or zones, of lighter colors: the light reds, light yellows, light blues, etc. Below the equator are bands of darker colors: dark reds, dark yellows, dark blues, etc.

Our maroon, then, belongs on a circuit below middle value, and in that part of the circuit devoted to red; daffodil yellow belongs above the equator, nearer white, in the yellow part of the circle.

Perhaps a red is at middle value, that is, half way between black and white. It may also be a definite red so that we are able to place it in its proper place in the hue circuit. But how shall we distinguish it from that fire wagon red which is also of middle value and definitely red?

We are imagining the sphere as solid in color. The central shaft is a series of grays—neutrals. If we start at the place on the equator where we have placed the red of our brick color and draw an imaginary line inward to the middle value gray, we will see this line passing through regular gradations of color from the easily discernible red of the brick to the neutral gray with no hint of red. The line passes through colors, all of which are reds, but each step inward grows grayer and weaker than the last. If, however, we follow the line in the other direction, away from gray, but traveling beyond the equator of the globe out into space we pass through steps of red, each stronger than the last, until we come to the red of our fire wagon. This is a strong, fully saturated color.

Between the strong red and neutral gray we may distinguish ten equal divisions, or steps of strength, which we term *chroma*. The red of the fire wagon is of the tenth chroma or ten steps out from neutral gray. The red of the brick which appears much grayer is only half as strong in chroma, or five steps out from neutral gray. The daffodil yellow would go out about as far as the red, but as it is much lighter we would find it on a higher level of value. The blue of the ocean is grayer than the strong red and also darker, or on a lower value level.

Now instead of considering the spherical globe alone as solid, so that we go out into space to reach these stronger colors, let us imagine the whole world of color as a somewhat irregular solid, with the strong color portions

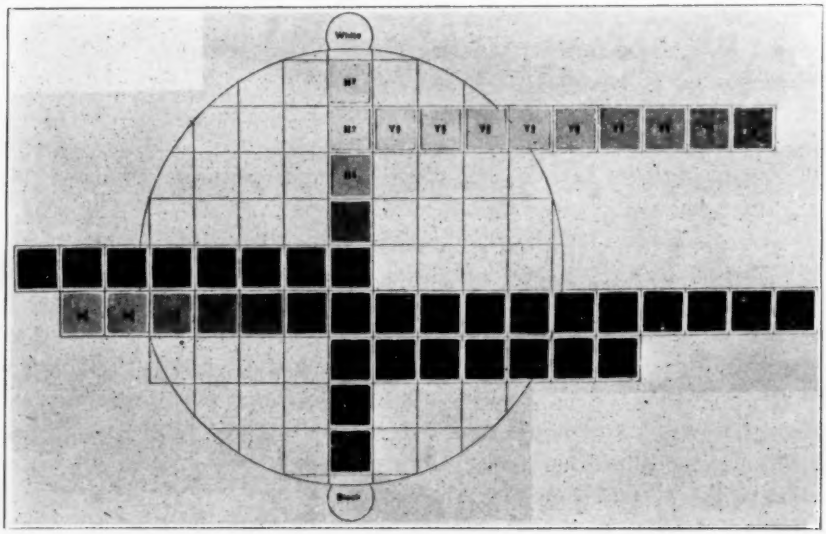


FIG. 2.—Chart C of the Munsell Atlas Chromatic Branches of the "Color Tree."

as mountains on a spherical world of color. Then the strongest red would be on a mountain peak ten units of measurement away from central gray, and the blue would be on the surface of the globe only five units out from gray, and nearer the south pole because it is darker. The yellow mountain would be nearer the north pole because it is lighter.

If we could cut vertical slices through this solid we would have exposed to view a vertical plane for each hue and its opposite. Thus, if we cut through red from north to south, or top to bottom, we would also cut through blue-green which comes opposite red on the hue circuit and there would appear before us a plane with black at the bottom, white at the top, reds on one half and blue-greens on the other half, a scale of neutral grays

in the middle with the chromas extending out from the neutrals, red to one side, and blue-green to the other. The reds would grade from dark reds at the bottom to light reds at the top of the chart, and from weak reds near the neutral scale out to strong reds. The blue-greens would do likewise. This is what we see on the charts of the Munsell Color Atlas. By cutting slices in this way we might form vertical planes in any of the 100 hues.

Or we may form horizontal planes by slicing our color solid from left to right parallel to the equator. If we cut through the equator we have a plane of color with radiating lines from gray in the center to all the hues about the circuit. All of these colors will be half way between black and white in value, none lighter and none darker, and they will vary in chroma from neutral gray in the center to the strong reds, greens and blues away from the center.

The lighter colors will all be found in the planes parallel with the equator but with higher levels of value, nearer to the north pole. The darker colors will all be in planes cut at lower levels, or nearer the south pole.

With this form in mind, how are we to write some sort of formula for the colors, say the two reds, in a simple and clear manner?

We measure hue around the circuit, dividing the whole into 10 principal hues indicated by their initials R, YR, Y, GY, G, BG, B, PB, P, RP. The red of our brick and fire wagon were the same red, having no yellow and no purple in them. Therefore they were pure red in hue, and this is indicated by the initial R (R = Red).

We divided our neutral value scale into ten steps. We find that the value of both these reds is 5, or half way between black and white. After the R we write the number 5 *above* a line, thus: R 5/. If it were a light yellow it might have been written Y 8/, indicating that the yellow was of the eighth level of value, or very light.

We divide our chroma scale, or radii of the circular plane into ten steps. The fire wagon red is at one extreme of the red radius. It is ten steps out from neutral gray. We write that figure after the hue, *below* a line, thus: R /10. Combining these figures in a formula we write R 5/10. For the brick color which is only five steps in chroma we write R 5/5.

This, then, is the formula whereby any color can be placed as closely as a pin point on the color solid: H V/C. H equals Hue, V equals Value, and C equals Chroma.

The hue is red	R
It is the fifth step of value	R 5/
It is the tenth step of chroma	R 5/10

We might have a light red vase with a slightly yellowish cast. It might be the ninth step in red (getting nearer YR) or 9R; it might be light in value (nearer white) perhaps at the seventh step of value—9R 7/; it might be weak in chroma, very near gray, perhaps the third chroma step—9R 7/3.

There we have it on paper. We could scribble this 9R 7/3 on a scrap of paper, tell our color man to produce a glaze of that color, and, provided he had the proper standards, he could do it.

This is a brief description of the idea of a clear thinking crystallization of color in measurable form. This scarcely begins to touch upon the possibilities of putting such a system into practice. But if one can grasp the idea of a world of color, every point of which is definitely placed and measurable, then in place of a vague and abstract idea, color has become for him a thing of positive utility.

NOTE: Further information as to more accurate hue nomenclature will be found in the Appendix of Mr. T. M. Cleland's pamphlet, "A Practical Description of the Munsell Color System."

Actual visualization of the various planes cut through the color solid with all the colors placed upon them in relation to hue, value and chroma is demonstrated in the Munsell Color Atlas.

SHOP NOTES—PLASTER SHOP

By T. A. Klinefelter and F. C. Parsons

ABSTRACT

This paper deals with the small problems which arise in the plaster shop, and are a source of annoyance and cost if handled incorrectly. The grade of plasters used, manner of handling, method of payment, extent of reinforcement of molds, care of benches, correct procedure in making the various parts and types of molds, are all touched on.

There are a considerable number of problems in connection with the plaster shop which are of vital interest to the terra cotta man. We say "vital interest" since in a way the whole shop itself is a necessary evil—being an indirect producer of high cost, and responsible for a large waste product.

The raw material handled by the shop is plaster of Paris. This material is variable in quality depending upon the purity of the crude rock to start with, and the degree and evenness of the burn in the making.

The color is a factor of small importance of itself. The burn is of great importance, however. A fast setting plaster may cause a good deal of trouble on large bulky pieces which are thrown up, by one layer setting too rapidly for good welding with the layer next to it. This is true on medium sized molds also where they are being built by piece workers. Also a very slow setting plaster is bad on account of undue time lost.

In going from shop to shop it will be noticed that some shops work on cheap plasters and some on high grade plasters. In general ware, sanitary or electrical porcelain, we use the finest plaster obtainable to get the maximum service out of a mold. Is it necessary to do this in terra cotta, however? It seems to us that the answer is both "yes" and "no." It depends upon the number of molds expected out of a case, or the number of pieces from a mold. Then too there is the extra expense of labor and space needed if a shop should try to work two plasters together. The saving in such a case might be more apparent than real.

This leads to the question of piece work versus day work. Although it is hard to develop a piece work system covering such varied shapes, it can be done.

But the point is, does it really pay? The answer must be qualified. It depends upon several factors. In the case of models where mistakes are very costly it is not likely that it is worth taking a chance on, unless the work handled were of a rather plain, uniform character. Molds, however, are different. Here the chance of error is reduced considerably. It is rather the quality of mold turned out that must be watched.

A piece worker will not work with casting in the ordinary run of molds, but will throw up as many as he can possibly handle at one time. This results in the first layers thrown starting to harden up too much before the next round comes with resultant mold breakage unless pretty rigid

supervision is exercised. Also, there is constant tendency to shallow chamfers, no joggle holes, and all sorts of free hand work with the emphasis on the *free* very largely.

However, what is the use of going to the other extreme and carefully pouring or casting a fine mold with all the care which a day worker can exercise, when that mold will likely turn out a few pieces only, perhaps a single piece even? As long as the mold will produce a good straight piece the once or twice necessary, it will answer just as well as if it had been made of such quality as to press 1000 pieces. There are, of course, some molds where it is foolish to insist upon a cheaply turned out proposition, but in the bulk of cases, the time and money saved are well worth realizing on, to say nothing of the better service rendered the customer by pushing his work through more rapidly.

In a shop working primarily on piece work, the tendency is always to go to the extreme, and for the management to think it should get the same degree of service out of a quickly thrown up mold that it can from a carefully cast one. This does not follow and it will be found that day work is necessary at times.

There is one point that might be raised here. Is it always necessary to do all the reinforcing with iron that is customary? It takes time to place these iron pieces. We are inclined to think that a considerable amount of iron work could be left out. Molds turning out from one to a few pieces need no such reinforcement, even when poorly made. When molds in other industries, with no iron, will stand the stamp of a machine plunger dozens of times surely a terra cotta mold can stand a few pressings. We are inclined to think that heavy iron work in all molds is a matter of habit, like a clerk using a slide rule who gets so that he multiplies 2×3 on the rule.

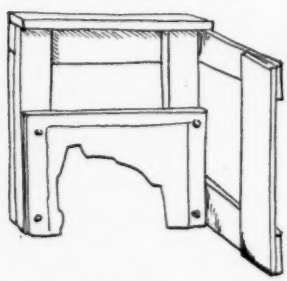


FIG. 1.

The making of a new horse mold for every template is another habit. A set of frames can be made up and the templates bolted in. (See Fig. 1.)

Machinery has never been developed to any great extent for the plaster shop though there are possibilities. The main machine remains the bench.

The importance of a level top cannot be too greatly emphasized. Usually the foreman is satisfied as long as the face of his piece is straight. But this is not enough. The bond must be straight also. Tops should be checked continually at regular intervals and dressed down accordingly. Level tops mean straight lines, right angles, and consequent saving of fitting costs.

There are a considerable number of things which the plaster shop can do that mean not only saving but better work in the finished goods, and these points should be most strenuously insisted upon. Slip-shod work on the models means trouble and lots of it. Markings for spray lines, numerals, letters etc., should all be clean and clear cut. Time is saved all along the line then.

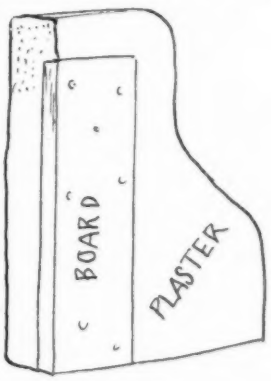


FIG. 2.

Molds which contain a number of pieces, such as panel molds, are often thrown up in a single piece and then sawed into the required number of pieces. This means an unsightly seam requiring a lot of extra finishing which is particularly bad in case of ornament.

Large heavy molds which are rolled over on account of the weight, and from which a considerable number of pieces are to be made, suffer a good deal of damage on the edge on which the turning is to be done. If a board is inserted along the edge, held in the plaster by nails having been driven in in slanting fashion, the turning will take place on the board and the mold will stand up indefinitely. (See Fig. 2.)

A prolific source of cracking along rebate lines, and wavy cornice lines is to be found in the manner in which the mold goes together, or the way it is taken apart. A large heavy cornice piece is sure to settle a bit when turned out of its mold. Suppose the mold is made in such a manner that the ends are the last pieces to come away—and this is usually the way a mold maker does the job—a glance at Fig. 3, shows that the end is heavily rebated and provision made for the outlookers. Naturally there is no chance for the clay to do any slipping and the ends are held rigidly against the end pieces of the mold. As a result the center of the piece between the two ends sags down. Also since the whole weight tends to rest on the rebate, a strain is set up resulting in cracking along the rebate line. The answer is to make the mold so as to remove the ends first, then the sides, and then the settle is distributed over the whole piece.

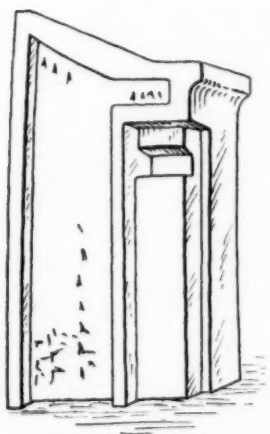


FIG. 3.

When pieces are faced on both sides as in the case of pilasters and columns, a good deal of difficulty is usually experienced in keeping exactly the same width for each piece if the mold is made in the ordinary way.

If the band iron does not happen to be tightly wedged, or if it slips a bit during the slugging, that piece will be a bit wider than it should be. Or a bit of clay may become gummed in where the sides and ends go together and result in the one end being a shade large, just enough to result in untidy looking work. The remedy here is the use of the case mold which is simply to cast or throw up an encircling case around the main molds. (See Fig. 4.)

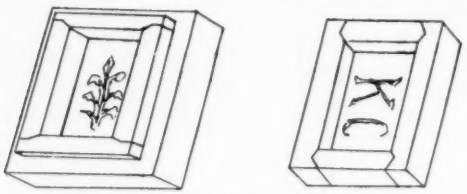


FIG. 4.

In general there is a tendency to do too much building of models where by the use of a little head work, the stuff could be handled on the running bench. If this point were watched more carefully a considerable amount of money would be saved in most shops.

The above items are a few illustrations of various little wastes and extravagances common to most plaster shops. There are many others and as can be seen by the method of dealing with those already described all that is needed by a foreman to pay his keep is a bit of common sense and ability to keep alive on his job.

NOTE: The authors wish to acknowledge their indebtedness to the Atlantic Terra Cotta Co. for permission granted in taking photographs and assistance in collection of data.

SHORT CUTS IN MITRE CUTTING

BY T. A. KLINEFELTER AND F. C. PARSONS

ABSTRACT

A discussion of the proper type of man to develop for mitre cutting, with hints as to quick and easy ways of doing the various processes involved in cutting and sticking mitres.

A department which is oftentimes much neglected, and not used to advantage is that of the mitre cutters. In proof of its standing in most shops, we believe we are safe in saying that very few plants pay the same rates and are as careful in the selection of their mitre cutters as they are in the care of their model makers. Yet, if anything, the reverse should be true. The chance for error is there although not so many pieces are as likely to be involved as in the case of a model maker's error. On the other hand he must handle thirty-five to forty pieces a day if he keeps his three finishers hustling as they should. So he must read his drawings much more rapidly, and just as accurately, as the model maker who dopes out about three pieces per day.

Again he must understand the handling of clays thoroughly so as to stick properly and get the correct shrinkage at the same time. And he must have brains to order his pieces properly so that those to be stuck together will be pressed the same day.

It is usually comparatively easy to break a mitre cutter into a model maker, but the reverse is not nearly so easy as it might appear. The loss of a mitre is costly in point of service, if nothing else. And the chance for loss is high in the case of poor sticking. Yet if mitres are properly made they should come through with a lower percentage loss than pieces which have been pressed by piece workers. The loss should never exceed $^1/_2$ of 1%.

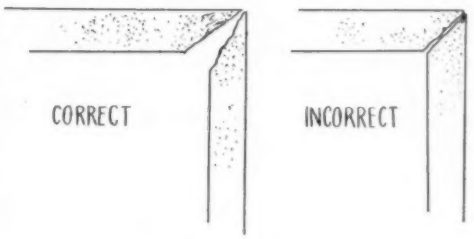


FIG. 1.

The first factor entering into proper sticking is the selection of the clay. The stiffness or moisture content of pieces to be stuck together should be the same. Yet this is regularly neglected and cutters are trying to stick pieces together which were pressed on different days, or dried at different rates. This is perhaps one of the largest sources of cracks. Another source of trouble which often results in crazed ware is the practice of letting a lot of stuff accumulate on the floor, as happens when there is a rush of work, and wetting it down to hold it in shape. After a good soaking the surface is wet and sloppy while the inside remains hard and continues to harden. After getting through the kiln the glaze often shows craze on a piece of this type.

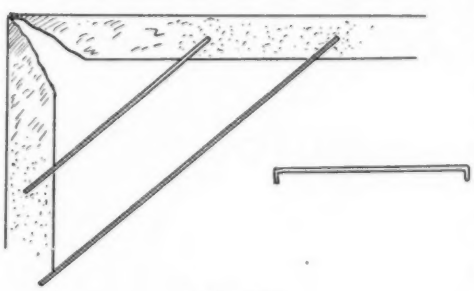


FIG. 2.

When it comes to the actual sticking, a good deal of carelessness is often the rule. It is very common practice to cut the mitre square and try to do the cramming and working in an eighth-inch crack. Instead, the face should be left full so that the edges come together and the back beveled away quite fully so as to leave a large opening to cram and work. All the work is done from the back, the front remaining practically untouched. (See Fig. 1.)

Needless to say we are assuming that the surfaces have been well and thoroughly forked to provide a good welding surface and necessitate the

use of a minimum amount of water. While doing the sticking an exceedingly handy device is the use of a couple of iron clamps which can be stuck across the top of the pieces. (See Fig. 2.) The mitre cutter inserts them just before turning the layout over to the finisher. The bottom edges are held on the board, of course. The clamps hold the top. The finisher can then work rapidly with little danger of bungling and distorting his work. Several lengths made of $^1/_4$-inch iron can be kept with the tools so as to be available instantly.

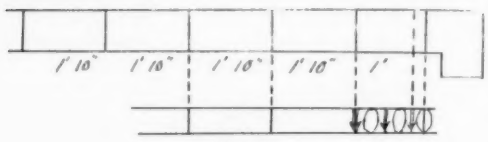


FIG. 3.

As the drawing office is primarily responsible for all clay work, it is here that someone must use headwork if the mitre cutting department is really worked to advantage. A great many models are often made up when a little clay work would do the trick and do it much cheaper. However, aside from that phase of the matter, a good deal of money is lost through lack of foresight if not boneheadedness. Take for instance running pieces of ornamental work: at the end of the course comes the mitre; next to the mitre a somewhat shorter piece than the regular running piece must be inserted. Will the draughtsman check up the ornament and see that his cut falls along the dart as it should? Generally not and the cut is likely to slice an egg squarely in two. This means that a modeler must get on the job and fix things up, perhaps spend hours at such work. A few minutes headwork would save the whole situation. (See Fig. 3.)

Take another common practice in regard to sills of varying length. The usual way is to take a piece as long as the longest sill wanted and start slicing off the end to the size wanted, at the same time sticking on a corresponding width of stool.

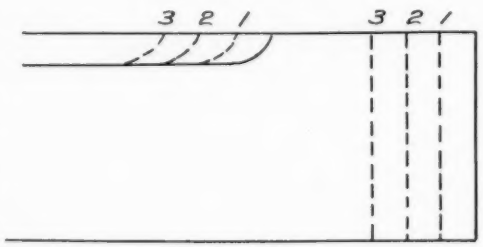


FIG. 4.

Why not foresee this, and have a stool long enough to cover all cases, then slice off the stool for the longer pieces? It is much easier to slice off than to stick. This applies to raised joints also. (See Fig. 4.)

This brings up the point of the ordering of clay pieces by the mitre cutter. He should order his piece so that after cutting the ends will remain. Otherwise he must stick one end, which runs a chance of cracking. The composite mold such as is used in pressing voussoirs is an interesting illus-

tration of how molds, money etc. can be saved by a bit of careful work.

A single mold with no chamfers, and an extra face can be used to make a whole flat arch. (See Fig. 5.) If the model maker lays out lines for every single piece and marks each line with its proper number, then the mitre cutter simply orders so many pieces out of each triangle number, the presser picks out the proper lines, makes his adjustment accordingly and delivers the piece. All the mitre cutter has to do is to set the pieces all together, to form the complete arch thus checking them all at once.

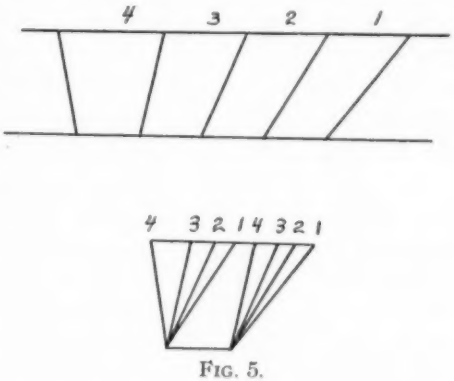


FIG. 5.

A device that is a big time saver is the use of a tin template when dealing with odd sized angles. The common practice is to keep checking the bevel square on the full size. If a good sized template is cut out it can be used throughout the job without stopping to check.

If a mitre cutter is of the proper type and training and continually on the lookout for saving time and expense on such matters as the above, the mitre cutting department becomes an exceedingly valuable adjunct and money saver.

NOTE: The authors wish to acknowledge their indebtedness to the Atlantic Terra Cotta Company for permission granted in taking photographs and assistance in collection of data.

TRENTON, N. J.

THE USE OF BENTONITE FOR SUSPENDING ENAMELS[1]

By M. E. Manson

ABSTRACT

Bentonite, a highly colloidal clay, has a much greater suspending power than the ordinary enameling clays. One part of bentonite is equivalent to five parts of clay. Its use enables the enameler to reduce the amount of raw materials necessary to add to his frit. Some disadvantages are pointed out.

Introduction

Within the past three years, considerable interest has been exhibited in the material known as "bentonite." This name has been applied to a certain type of clay-like mineral having very peculiar physical properties. The material has no fixed chemical composition, and samples from different localities may vary widely in color and fracture. Its distinguishing characteristics are its colloidal properties, its peculiar ability to absorb several times its weight of water and its soapy feel when wet.

Although the material has been known for many years, its use was very limited until 1920. Probably its chief use during this period was as a base for the medical dressing, "antiphlogistine." Since 1920, however, as a result of investigations by several organizations, including the Forest Products Laboratory at Madison, Wisconsin, many uses have been found for bentonite. Those who may wish further information concerning this remarkable material, are referred to a bulletin issued by the Bureau of Mines.[2]

In the present paper, its adaptability to use as an enameling clay is taken up. The only property of the bentonite investigated was its ability to keep enamel suspended in water. The experiments with ground coat for dry process enameling were conducted at the plant of the Rundle Manufacturing Company, those with wet process ground and cover coats at the plant of the A. J. Lindemann-Hoverson Company. Both plants were using enameling clays which are well known to enamelers, and it was against these that the bentonite was compared. Throughout this paper, the enameling clays used are referred to simply as clay, while the bentonite is referred to by name.

Use in Ground Coat for Dry Process Work

As a preliminary test, 20 grams of white enamel powder, 100% through 60 mesh, were placed in each of two glass tubes, with 20 cc. of water. To one tube 5% clay was added, to the other an equal amount of bentonite. Both tubes were shaken vigorously for ten minutes then allowed to stand and the time required for settling noted. The tube with clay was completely settled in four hours. The tube with the bentonite had not begun to settle at the end of three weeks, at which time it was cleaned out.

[1] Presented before the Enamel Division, Pittsburgh Meeting, February, 1923.

[2] R. B. Ladoo, "Bentonite," Bur. Mines, Repts. Investigations, No. 2289.

This rough test indicated that the bentonite had a very high flotation power, and immediately suggested that satisfactory results might be achieved with much less clay than is required when using the ordinary enameling clays. Before proceeding with laboratory tests, a regular factory batch of ground coat was ground, keeping all weights the same, but substituting bentonite for clay. The batch consisted of frit, 200 pounds, borax 4 pounds, water 100 pounds. In our standard practice, using $2^1/_2\%$ of clay, the finished product was fairly fluid, requiring just a little thinning for use. This experimental batch, at the end of grinding, was of the consistency of soft butter, and would not flow out of the mill. It was necessary to add again as much water to bring it to the proper consistency.

A series of laboratory tests was now run, using a small pebble mill for grinding. The general scheme was as follows. In each case 200 grams of frit and four grams of borax were taken. Clay was varied from five grams to one gram, or $2^1/_2\%$ to $^1/_2\%$ and sufficient water was added so that the final product had approximately the same consistency in each case. Consistency was determined by a viscosity or mobility test, in which the time required for 25 cc. to run out of a 25 cc. pipette with a large orifice was noted. An arbitrary figure of five seconds was taken as standard, since ground coat at this viscosity seemed about right for use. The results are given in Table I:

TABLE I

Test No.	1	2	3	4	5
Frit	200 gms.	200 gms.	200 gms.	200 gms.	200 gms.
Clay[1]	5 gms.	5 gms.	3 gms.	2 gms.	1 gm.
Borax	4 gms.	4 gms.	4 gms.	4 gms.	4 gms.
Water	120 cc.	230 cc.	160 cc.	145 cc.	135 cc.
Viscosity	$4^4/_5$ sec.	$3^1/_5$ sec.	5 sec.	5 sec.	$4^4/_5$ sec.

[1] Clay used in No. 1, bentonite in all other tests.

After determining the viscosity of each batch, 50 cc. was poured into a glass tube, and the amount of settling noted. This was expressed in per cent of the height of clear water visible to the total height of the material in the tubes. At the end of two days, Numbers 1 and 2 had settled about 7%, while 3, 4 and 5 had settled about 3%. Scarcely any further settling took place in any of the tubes after the first two days. As is evident from the viscosity determination in test 2, too much water was added to it. Had its viscosity been 5 seconds, I believe there would have been even less than 3% of settling.

The above tests indicate that there are two methods of using bentonite. One can use the same amount of clay, and get a greatly increased volume of enamel or one can use a great deal less clay to get the same volume of enamel. The second method would seem the more desirable, inasmuch as a certain volume of enamel is usually applied to a piece, and in the first

method this volume would contain much less enamel by weight than in the second.

With this information, a plant test was made in which ground coat ground with 1% bentonite was compared with the same frit ground with $2^1/_2$% clay. Accurate burning tests showed that the ground coat with bentonite was a trifle softer, or more fusible than the other, but when the bentonite ground coat was used exclusively over a period of three weeks, there was no noticeable difference in the quality nor amount of ware turned out. On the other hand, the ground coat stayed in suspension much better than it had ever done before. Since the cost was about the same in each case, we came to the conclusion that the advantage lay with the bentonite.

Use in Wet Enamel on Steel

As mentioned above, this work was carried on at the plant of the A. J. Lindemann-Hoverson Company, and was under the supervision of Mr. Atkinson of that company.

In their standard practice, ground coat for sheet steel is ground with 5% clay. When bentonite was substituted, they found it necessary to make a drastic cut in the percentage used. This percentage was therefore reduced by progressive stages, until $1^1/_4$% was finally chosen as being about right. This checked our own experience, showing that one pound of bentonite was equivalent to five pounds of clay. Operations with this ground coat were, however, not wholly satisfactory. While its consistency was the same as the standard, there was a difference in the working properties. In using the standard batch, a coated piece would drain for a moment, and then apparently "set," or congeal, on the ware. On the other hand, the ground coat with bentonite would drain nearly indefinitely, if allowed. The reason for this is not clear. It is possible that the "set" occurring in the standard ground coat is due to rapid evaporation of water from the surface of the piece, while the very great affinity of bentonite for water prevents such evaporation.

There was an added difficulty, in that it was nearly impossible to thicken a batch which accidentally became too thin. Ordinarily if a batch became thin, it was allowed to stand overnight when the excess water could be skimmed off the top. With the ground coat containing bentonite, no amount of standing ever brought any water to the top; attempts to thicken it by introducing some very thick ground coat were not very successful, due to the great difficulty of getting a thorough mixture of the two lots.

This is a record of the chief faults of the material in Mr. Atkinson's estimation. It would seem to the writer, however, that the absence of settling where bentonite is used might, in some circumstances, be more of a virtue than a vice.

In order to secure some of the advantages of the bentonite, without its

disadvantages, a series of tests was run, using a combination of bentonite and clay, the combination finally chosen being $2^1/_2\%$ clay, plus one-half per cent of bentonite. This worked fairly well and is, I believe, in use now, but its advantages are doubtful.

It would appear to the writer that the greatest field for bentonite would lie in the wet process finish coats, especially white coats. Generally, from 8% to 14% of raw material is added to the frit in the mill, of which 5% or 6% is clay. Since this raw material has no gloss itself, its presence in the frit must have some effect toward reducing the gloss of the finished piece.

Anything which would reduce the amount of raw addition to the frit, would therefore seem very desirable. One test of this idea was made, with a white enamel for sheet steel. According to Mr. Atkinson, the gloss of the resultant enamel was seriously impaired, instead of being helped. In fact, the results were so unfavorable, that no more work was done along this line. This report, so entirely opposite to that expected, led the writer to make up some test pieces in the laboratory, of white, wet enameled cast iron. Enamel ground with 5% clay was compared with the same enamel ground with 1% bentonite. There was very little difference in the gloss of the two enamels, but if anything, the bentonite enamel had the best appearance. This would lead one to believe either that some enamels are adversely affected by the bentonite while others are not, or that something else caused the trouble with the steel enamel.

Conclusion

From the few experiments just outlined, it seems evident that by using bentonite as an enameling clay, the amount of raw addition to an enamel can be greatly reduced. Theoretically, the finish of the resultant enamel should be improved, although further experimentation may disprove this. Even in the small amount necessary, bentonite has a greater suspending power than other clays, which should be of advantage to those enamelers who coat with spray guns. But difficulties of manipulation are apt to turn up, which may more than offset the advantages of the material. This paper does not pretend to more than scratch the surface of the subject. Should others investigate further, they will no doubt discover many facts which we have overlooked.

The bentonite used in this work was obtained from the American Colloidite Company of Chicago, who market it under the trade name, "Colloidite." For other sources of supply see the Bureau of Mines, *Bulletin*, mentioned above.

NOTE: The writer wishes to express his appreciation of the coöperation given by Mr. W. C. Lindemann.

RUNDLE MFG. CO.
MILWAUKEE, WIS.

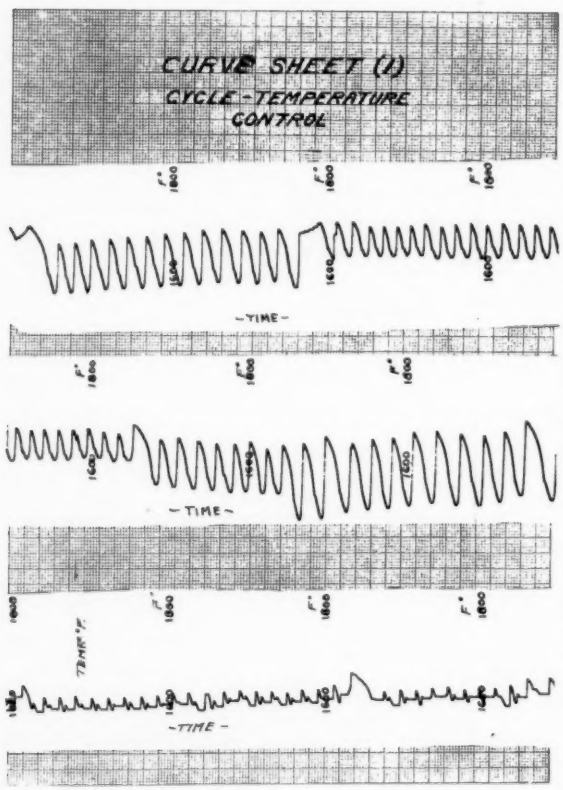
VITREOUS ENAMELING WITH ELECTRIC HEAT[1]

By E. F. Collins

ABSTRACT

This paper is descriptive of the suitability of the metallic resistor furnace for the application of vitreous enamels. Comparisons are made with fuel fired furnaces. Uniformity and perfect fusion of enamel results from the high grade temperature control of the electric furnace. Atmospheres vitiated with products of combustion can not be present in the electric furnace to give defective coatings. Examples of operating furnaces for watch dials and for bath tubs are given and the average performance, in time and input, for bath tub furnaces. It is believed by the author that the electric heating process can not long be considered as anything but the most economical over all, and its standardization for this purpose will eventually result.

The enameling of metals is a relatively old art and had its beginnings prior to 1300 B. C., when the Assyrians and Egyptians used it in decorations for palaces and gifts. It has in the last few years developed into a modern industry of no mean size. The modern industry includes not only the manufacture of decorative materials but also the productions of enameled sheet steel and cast iron wares, considered as modern standards of durable and sanitary equipment in universal use.



Vitreous enamels are simply glasses with low melting points, fused to the surface of metals or anything which will withstand the fusion temperatures.

There are four general methods for applying the slip or enamel in preparation for baking it upon metal: first, slushing, or dipping the ware into the slip and the shaking it to give a uniform coat; second, dipping and then permitting to drain; third, spraying for complex shapes

[1] Presented before the Enamel Division, Pittsburgh Meeting, February, 1923.

and even flat simple shapes; fourth, dusting or dry process, used generally on cast iron and heavy steel shapes. This process is used for bath tubs, sinks and similar ware.

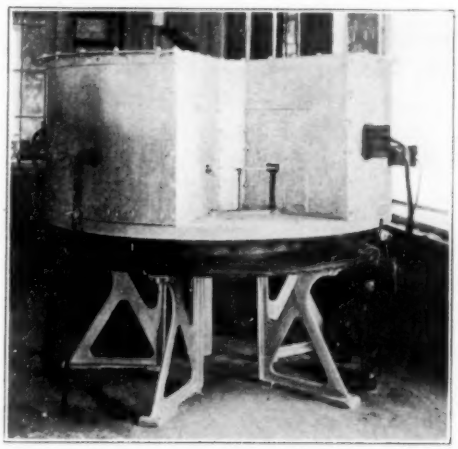


FIG. 1.

Several types of furnace have been used in the past for the baking or burning of enamel ware. These differed mainly in the method of heating. When gas is used a semi-muffled heating chamber may be employed, but when coal or fuel oil is used then a full muffle is necessary.

One essential feature in the furnace is uniformity of temperature throughout the furnace, even though the flow of heat is decidedly different and varies in different parts of the baking chamber. Uniformity of temperature depends upon the type of furnace used and upon its design.

Within the past four or five years the electric furnace has steadily and continuously demonstrated that it is without a peer when the results from its use in baking vitreous enamel are compared to fuel fired furnaces. In this type of furnace the control of heat flow is so complete that uniform temperature may be applied in baking a complex shape, even though the heat flow or heat quantity varies in different parts of the charge. I refer to such parts as apron bath tubs. Here no difficulty is met in delivering the required amount of heat at the same temperature on either the apron or reverse side of tub. Such manipulation of heat is, of course, impossible with other than the electric furnace.

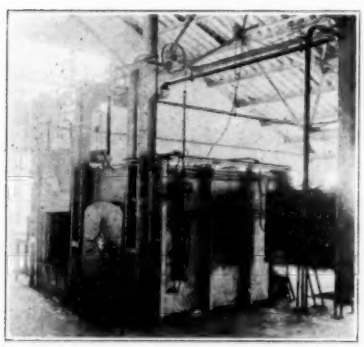


FIG. 2.

The metallic resistor type of electric furnace is the one with which this paper deals. Such furnaces are equipped with automatic control of temperature and operate at temperatures of 1900°F or better, which cover the ordinary requirements of 1800°F for ground coat, 1750°F for first finish coat and 1600°F for finish coats.

Due to the perfect heat control in these electric enameling furnaces, they

show a greater output for the same furnace hearth than the fuel fired furnace. The time of burning is dependent upon the cooler portions of the fuel furnace and a compromise must be made between hot and cold portions of the furnace which may result in some parts of the charge being slightly under-fired and other parts being slightly over-fired. If the furnace has large variations the ware must be turned.

Strictly speaking, to insure a uniform product, the furnace must be capable of maintaining a constant operating cycle of temperature rather than a constant temperature, *i. e.*, during the normal working of the furnace the temperature will vary from the maximum just before charging, followed by a sudden drop in temperature when the furnace is charged, which again rises as the charge becomes heated.

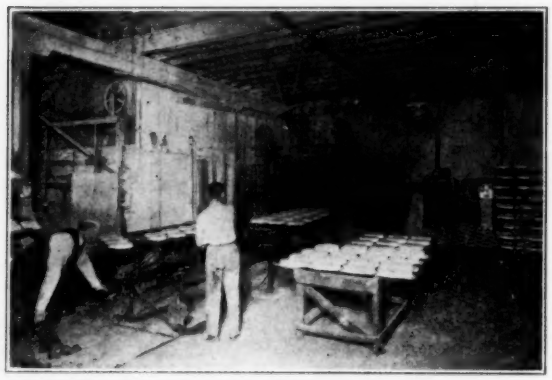


FIG. 3.—Vitreous enamel furnace working chamber, 10 ft. deep, 4 ft. wide, 2 ft. high. Connected load 140 kw., 220 volts, 3 phase, 60 cycle, 1700°F operation. St. Louis Brass Company, St. Louis, Mo. Firing vitreous enamel at 1650°F.

If this cycle of temperature can be made to occur regularly and identically, then the furnace has a controllable temperature suited to the work of vitreous enameling. Such performance is shown on curve sheet (1). This chart shows uniform cycles of temperature for light and heavy work in the electric furnace.

In addition to temperature control the electric furnace is possessed of a long life and low power consumption.

Sulphur fumes which are injurious to enamel ware are absent in the electric furnace, and hence its use secures against high percentage of rejections from this cause.

Again the electric furnace has no muffles to give trouble, such as is experienced with coal and oil firing.

The electric furnace has been able to handle 170 heats in 10 hours as against 130 heats with the coal fired furnace. Heats have been completed in 50 seconds that would require 3 minutes and 40 seconds in the oil furnace.

It is desired to call attention here to a few installations of the electric furnace for the baking of vitreous enamel. These furnaces range from one which is enameling watch dials to those handling the largest size of bath

tubs, and they have shown to be uniformly satisfactory for all classes of work on which they have been used.

In Fig. 1 is shown a furnace for enameling watch dials. Mean diameter of hearth is 3 feet, width of hearth is 2 inches. Heat is furnished by 30 kw. metallic resistors. Production is 15 dials per minute. This furnace is reported as saving $50.00 per day in labor charges alone. The output of dials is essentially 100% perfect as against 40 to 60% good dials in the combustion furnace which it replaced.

In Fig. 2 is shown a larger type such as is used on bath tub enameling. It has for dimensions a heating chamber 9 feet long, 5 feet 3 inches wide and 4 feet 3 inches high, and is equipped with 200 kw. resistors. A furnace of this type is guaranteed to produce four tubs per hour with a kw. consumption of 50 kw.-hr. per tub. In other words, the user of such a furnace may expect a production about as follows:

On $4^1/_2$ foot, 5 foot and $5^1/_2$ foot rolled rim tubs the burning time for a complete tub will vary from 13 minutes to 17 minutes. This is the time for what is commonly known as three coat work, namely, one ground coat and two white coats.

The average output per furnace of the above sizes is about 4 tubs per hour with an energy consumption somewhat less than 50 kw.-hr. per tub.

The average output of the above sizes is about 4.09 tubs per hour at a cost of 48.96 kw.-hr. per tub for each furnace.

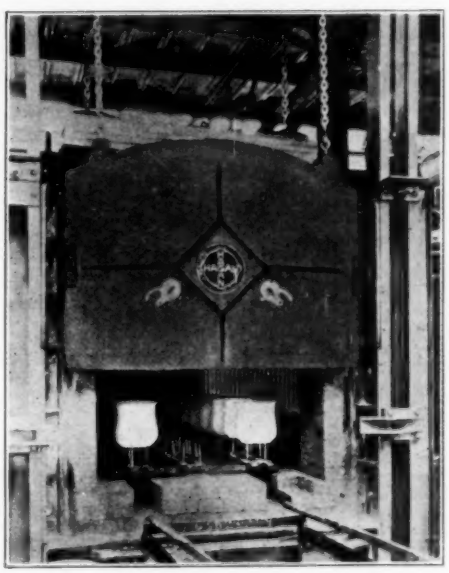


FIG. 4.—End view double chamber electrically heated vitreous enameling furnace, Coonley Manufacturing Company, Cicero, Ill. Each chamber, 8 ft. long, 42 in. wide, 2 ft. high. Connected load of each chamber 117 kw., operating temperature 1750°F.

In Fig. 3 is shown a vitreous enameling furnace with baking chamber 10 feet deep, 4 feet wide, and 2 feet high. This furnace has been operating more than two years and the users report that it is superior in many ways to the fuel fired furnace formerly used by them. They state that the "over-all" cost of product is less than for the fuel fired enameling furnace. The upkeep has been practically nothing compared to the cost of upkeep of coal or oil fired furnaces doing the same duty.

In Figures 4 and 5 are shown views of a furnace operating on enamel ware of the lighter domestic class. Here again the manufacturer using it speaks highly of its performance and states that its use gives a lower "over-all" cost for his product than did the coal or oil fired furnace. Better working conditions especially in hot weather are given by the user of this furnace as a great advantage.

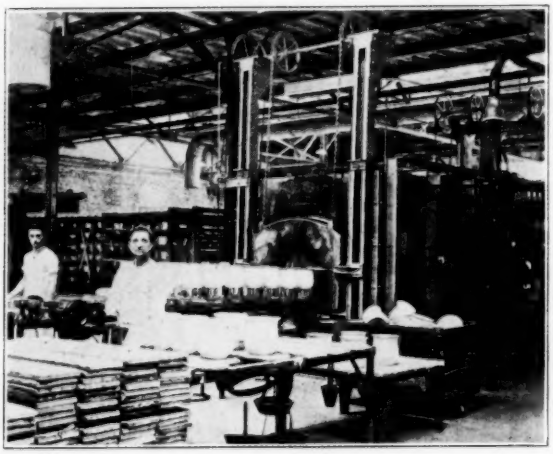


FIG. 5.—Double chamber electrically heated vitreous enameling furnace, Coonley Manufacturing Company, Cicero, Ill. Each chamber 8 ft. long, 42 in. wide and 2 ft. high. Connected load for each chamber 117 kw., operating temperature 1750° F.

The writer hopes that what he has said here will encourage those who have not done so to investigate the merits of the electric metallic resistor furnace for vitreous enameling. He sincerely regrets that he is unable to present, at this time, more definite data regarding all installations recently installed as well as all those which have been operating for many months.

Much data of this nature has, however, been rather jealously guarded by several who have used this type of furnace, for the reason perhaps that they are not anxious to have their competitors realize too soon the advantage they have secured for themselves through the use of the electric furnace. It is hoped, therefore, that these few statements concerning the electric furnace may determine others to decide that they will not longer be denied the aid which electric heat offers in this vitreous enamel process.

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

PRODUCER GAS FOR BURNING REFRACTORIES[1]

By W. D. Richardson

ABSTRACT

History of installations in the United States of producer gas for burning fire brick. Causes of failure or abandonment of producer gas firing. Continuous regenerative kiln necessary for successful burning at high temperatures with producer gas.

The compartment kiln, fired with producer gas, best adapted for general refractories. Advantages of the compartment kiln over the car tunnel kiln. Essential features of continuous kilns for the successful burning of refractories. Special features of gas producers for ceramic kilns.

Temperatures from producer gas. Economy of producer gas as compared with natural gas, oil and powdered coal. Investigation of designs and methods of operating gas producers.

Introduction

It has now become quite generally recognized by engineers of metallurgical plants that producer gas has a wider application in operations requiring high temperatures and is more efficient and economical than any other kind or form of fuel. Hence, the gas producer is almost universally found in steel works and glass factories. Moreover, probably in no country has the gas producer been so highly developed as it is in the United States of America. The question naturally arises then, why is not producer gas more extensively used in the clay industries, especially for high temperatures?

The literature of our Society contains several papers on producer gas, but none on the application of this fuel to the burning of refractories. In Europe, producer gas has been successfully used for more than forty years in the burning of high grade fire brick. In this country, several trials have been made of producer gas in fire brick plants, but for one reason or another the results have not been satisfactory, and the kilns or the gas producers have been torn down or abandoned. So far as I know, producer gas is not in use today in this country for the burning of fire brick. It may be interesting to give a brief account of the installations of gas producers in fire brick plants in this country, so far as I have myself observed or record of which I have been able to find.

Historical

The first use of producer gas in the burning of fire brick in America, that I know anything about, was at the Mount Savage Fire Brick Works. There were two tunnel kilns (not car kilns) fired with producer gas for about twenty years, from 1890, or a little before, to 1908. The suction gas producer was on a car that was moved back and forth on a track on one side of the kiln. The gas was conducted by sheet iron pipes to the ports

[1] Presented before the Refractories Division, Pittsburgh Meeting, February, 1923.

in the top of the kiln. When first installed, these producers were charged through bell hoppers on top, but when I saw the kilns in operation, in 1904 and 1905, the bell hoppers had been removed and the producer was charged with a shovel through a door in one end. In fact, the producer was nothing but a big oblong stove with a thick fuel bed on a cast iron grate. The gas, being fired at the top of the kiln, of course would not burn the brick hard to the bottom, so coal was also fired through holes in the top, in the usual manner.

Mr. J. P. Biays, Vice-President of the Union Mining Co., writes, "As long as the foreman, who was at Mount Savage when I went there in 1901, lived the kilns were operated with comparative success. After his death, the operation of the kilns was not considered successful and they were done away with."

The first producer gas-fired kiln that I ever saw was at a plant of Harbison-Walker, near Pittsburgh. There were two kilns in operation there from about 1894 to 1902—a Dunnachie kiln of ten chambers and a Mendheim kiln of twelve chambers. As my visit there was only for an hour or two and as I then knew practically nothing of producer gas nor of continuous kilns, I have no distinct recollection of the equipment nor of the results obtained.

Mr. James Dunnachie, Glenboig, Scotland, in his paper before the English Ceramic Society in 1908 on "The Dunnachie Continuous Regenerative Gas Kiln," gives a letter from Harbison-Walker Refractories Co., from which I will quote:

> As far as the consumption of coal is concerned, our saving of fuel with these kilns amounts to 40 or 50 per cent over the ordinary or old form of direct fired kilns..... Several years ago we sold the plant at which these kilns were located, and have not constructed any more of them, for the reason that repairs on the gas form of kiln are considerably greater than those on the old fashioned or ordinary form. In addition to this, the interest charge on the first cost is at least double that on the old form of kiln. We found that these extra repairs and extra interest cost amounted to as much as our saving in fuel.
>
> This simply means that the gas kilns are not an advantage where fuel is extremely low. For instance, at the time we were using your kiln, we were buying coal at 60 cents a ton delivered at our works. Forty per cent saving of fuel at this price does not amount to much, but if we had been paying two dollars and upwards the saving, as you can easily figure out, would amount to several times more. Therefore, where fuel is high priced, the gas kiln is a great advantage over any other form we know of and, as previously stated, we would decidedly prefer your form of construction.

On this letter Mr. Dunnachie comments as follows: "What the writer says about the cost of repairs surprises me. My experience is that gas firing is much easier on the brickwork than coal firing."

I will say also that my own experience, as well as that of others in this country, is to the effect that producer gas damages a kiln much less than

direct coal firing. A battery of rectangular chambers, however, unless properly designed and built, may cause excessive repairs from expansion and contraction of crowns, especially if fired only on one side.

The next producer gas-fired kiln that I know of in a fire brick plant was built at the works of the Christy Fire Clay Co., about 1905. This was probably designed after German plans, as the drawings were made by Mr. Geo. Vater, who was a graduate of a German Ceramic School and had had some experience in fire brick works at Grosalmerode. Though I recommended Mr. Vater for this job, he having worked for me as a draftsman, yet I did not see the kiln until the visit of our SOCIETY to the plant in 1908. I do not remember much about the kiln, except that it had the old Siemens Gas Producer in a pit below the surface of the yard and that the gas came into the kiln through the floor. We know now that the kiln could not have served its purpose well and we think it was in operation only a few years. Answering my letter for information about this, Mr. R. D. Hatton, Vice-President and General Manager of the Laclede-Christy Clay Products Co., writes: "The Christy Fire Clay Co. did build a continuous gas tunnel kiln some years ago, which, as far as we recall, was planned and designed by Mr. Vater in collaboration with Mr. Miller. Our records are incomplete, in fact we are unable to trace any record as to results of this installation, but you have made a correct statement that we did tear the kiln down."

In 1918 I was doing some work for the U. S. Shipping Board at the fire brick works of the Didier-March Co., Keasby, N. J., and saw there a large producer gas-fired continuous kiln, which had not been in use for some time. This kiln was of German design and the mechanical producers were made in Germany, in fact the whole plant was 100 per cent German, and had been taken over by Palmer. I could get no information of their experience with this kiln, but it evidently was not satisfactory, or such a costly installation would not have been abandoned. My impression is that the kiln, which has since been torn down, could have been modified to give very satisfactory results.

Causes of Failure

Evidently no single cause can be given for the failure or abandonment of these attempts to use producer gas for the burning of fire brick. In some cases, undoubtedly, the gas producer caused a lot of trouble, but in most cases, the method of conducting the gas into the kiln and of distributing and regulating it was faulty, and probably in all cases there was a lack of practical knowledge of the generation and application of producer gas to the burning of clay products. Moreover, it should be noted that in those days there was not available the controlling apparatus that is now so extensively used. In general, it may be said that the pioneers in any

improved process are sure to have troubles and few there are who persevere until these troubles have been overcome. This does not mean that all attempts in this country to burn fire brick with producer gas have been failures, so far as obtaining good burns, but that under past conditions of cheap fuel and cheap labor continuous kilns and gas producers may not have been the most economical equipment.

Progress

We have learned a lot about the construction and operation of gas producers since then and, what is more important, we have learned how to construct a continuous kiln for the burning of producer gas. This increased knowledge is not due to the work of any one man, but has been gradually developed from the work of many, as the records of the Patent Office show. Looking over these patents, with the light of our own experience, we see some good features in nearly all of them, but most of them lack some feature essential to practical success, and most of them, fortunately, never got beyond the Patent Office, that is, no one sunk any money trying them out.

The Compartment Kiln

All know that for attaining high temperatures, such as are required in the fire brick industry, producer gas must be served hot, not only must the gas be hot as possible, but the air for combustion must be hot. These conditions can only be successfully met with the continuous regenerative compartment kiln. To be sure, with proper recuperation and insulation high temperatures can be attained in periodic kilns, and, under certain conditions, this may be practical, but, with the compartment kiln that we have today, the periodic kiln should only be used on small plants or for special requirements.

The Car Tunnel Kiln

But what about the car kiln? This form of continuous kiln is being most vigorously promoted and its development is being watched with much interest by all clayworkers. It undoubtedly is the ideal kiln and will be used more and more in the clay industries, but its use is likely to be retarded somewhat by the promoters who recommend it for every condition and purpose. The fact should be kept in mind that no single form or type of kiln is, or every will be, best for all conditions and purposes.

There are certain inherent disadvantages that, I believe, will always keep the car kiln from being as suitable for general refractories as the compartment gas kiln. Some of these are:

1. In a car kiln the products should not vary greatly in size, so that the

time required in heating up, soaking and cooling down of every car will be practically the same. In the fire brick industry it is often necessary to burn shapes varying a hundred pounds or more in weight. In the compartment kiln the separate chambers may be set with different sizes and kinds of ware and the gas easily regulated so as to give every chamber the requisite time and temperature for best results.

2. It is economically necessary that the time of cooling the car kiln be rapid. The compartment kiln is designed for slow cooling, which is sometimes desirable for large bodies.

3. To make the car kiln economical for heavy clay products, the cars must be fairly wide and, as the fires must be on the sides of the tunnel and the draft longitudinal, there must be considerable difference in temperature from the sides of the car to the center, and no system of cross firing can entirely overcome this. To be sure, this may be largely overcome by a weak draft and a reducing fire, but in burning fire brick, oxidizing conditions are generally desirable. Even if the cars pass through a muffle, this remains true to a certain extent, and it is a question whether the muffle kiln is not too costly, in construction and upkeep, for general refractories.

4. In the car kiln, when repairs are necessary, the operation of the kiln must cease entirely, while in the compartment kiln there need be no shut down for repairs and generally repairs can be made without interfering with the regular operation of the kiln.

Personal Experience

My experience with producer gas began in 1910, when I was called to take charge of a face brick plant having a Youngren Compartment Kiln. My early struggles with this kiln were related to the SOCIETY and can be found in Vol. 14 of the *Transactions*.[1] Though I had not at that time made changes in the kiln or gas producer, yet I then made the statement in my conclusions, "This type of kiln is the best that I have ever used for the burning of face brick." Since then I have, as superintendent, manager or consulting engineer, had almost constant experience with producer gas and the compartment kiln, and have been able to make such improvements in gas producers and compartment kilns for producer gas fuel that I have become convinced that producer gas is the most practical fuel today in most situations and is *the* fuel of the future.

Though I have never used producer gas in the burning of refractories, yet I have used it in the burning of face brick from a clay requiring as high a heat to produce a hard body suitable for facing as is used in most fire brick plants. Our light-buff, dry-pressed face brick at Hebron were burned to cone 8 and to cone 10 in the bottom, two courses above the

[1] *Trans. Amer. Ceram. Soc.*, **14**, 778 (1912).

floor. Our coal was Dakota lignite, from which we generated gas and fired a compartment kiln of my own design, compartments 18 ft. wide by 43 ft. long and 10 ft. high, inside measurements, holding about 65,000 standard brick. The kiln was designed for burning a compartment every 48 hours. Our regular time of burning was 36 hours, but the burners occasionally got in a hurry and finished a compartment in 24 hours, putting down cone 10 on the bottom.

The Continuous Kiln for Refractories

All will admit that the principle of the continuous kiln is absolutely correct. With the knowledge and experience that we now have, this economic principle can be applied successfully to the burning of refractories. I want to specify certain features that must be recognized and followed in order to attain the desired results:

1. The kiln must be a compartment kiln or a car tunnel kiln.
2. The compartment kiln must be fired with a gaseous fuel, from coal or oil.
3. The compartment kiln must be down-draft and fired from both sides of the compartment. The gas and air, in proper proportions, must be mixed in combustion bags, close together. The floors must be perforated so as to secure an even distribution of heat.
4. The gas must be brought to the kiln in underground ducts, well insulated from moisture, and evenly distributed to ports in the bottom of the combustion bags, underneath the air. The distribution of the gas must be under perfect control by valves within easy reach of the burner while he is looking in the peep hole on a line with the tops of the combustion bags.
5. The gas must be brought to the combustion bags as hot as possible, without superheating other than is given by the distribution ducts in the kiln.
6. The air for combustion must be as hot as possible and the amount easily regulated.
7. It should not take more than 48 hours to burn to the highest temperatures desired, in every part of the compartment.

Gas Producers for Kilns

There are now some good gas producers on the market, both hand-stoked and mechanical. The advantage of the mechanical producer is chiefly in its greater capacity per square foot of area of fuel bed. A good hand-stoked producer will gasify 10 to 15 pounds of coal per square foot per hour. A mechanical producer will gasify 30 to 40 pounds of coal per square foot per hour.

Where only one producer is required, the mechanical producer also has the advantage of giving constantly a more uniform quality and temperature of gas. Where two or more producers are used and fired alternately the hand-stoked and hand-poked producer answers all requirements for quality of gas and, where only a few producers are required, is also cheaper to operate.

For ceramic kilns the gas producer should have the following special features:

1. It should operate without serious difficulty on any kind of coal.
2. The cost of the producer and the installation should not be excessive. The efficiency of a gas producer cannot always be judged by the price at which it is sold.
3. The cost of operation and for repairs should be light.

I have used mostly the rectangular producer, built up of brick, and have found it very satisfactory, when properly designed and constructed. To increase the capacity and give a more uniform gas I have recently equipped this producer with an automatic feeder and distributor. This leaves nothing to be desired in efficiency, except with a badly caking coal. I have not yet found it necessary to use a coal requiring an automatic stirrer to counteract the caking. The rectangular producer has decided advantages over the round producer and substantial brick walls give better insulation than steel casings, give no trouble from cracking and leaking, cost less and will last forever.

Temperatures from Producer Gas

Just how high a heat can be obtained in a compartment kiln with producer gas I cannot say. Knowing the composition of the gas and the temperature at which it is applied, the temperature of the air for combustion and the quantity of air used, the combustion temperature of the gas can be calculated. Lovejoy and Garve, in their paper on "Kiln Temperatures from Coal and Producer Gas,"[1] made elaborate calculations of temperatures obtainable from producer gas with Texas lignite. They found the combustion temperature of this gas at 500°C, 30% moisture, 125% air at 1000° and 20% radiation loss, to be 1382°, a little higher than cone 12. As I have put down cone 12 with producer gas from Dakota lignite, I know that their figure is not too high. How much higher I could have gone I do not know. At any rate the excess of air could have been less and much of the time the air for combustion would have been at a higher temperature than 1000°. Moreover, in such a kiln as I used, there could be no radiation loss in the combustion bags and the radiation loss from kiln would not affect the combustion temperature, but only the

[1] *Trans. Amer. Ceram. Soc.*, **12**, 93 (1910).

amount of fuel required to make up this loss. In each compartment of this kiln there were 28 fires. That is one advantage of a gaseous fuel, that a much larger quantity of fuel can be introduced and burned in the kiln. While this does not affect the combustion temperature, it does enable a kiln to be brought to the highest possible heat in all parts in the shortest possible time. Undoubtedly, under certain conditions, the temperature of combustion of the gas from a given fuel is increased by the steam blown into the producer to keep down the clinker, but on this point I have been unable to find any definite data.

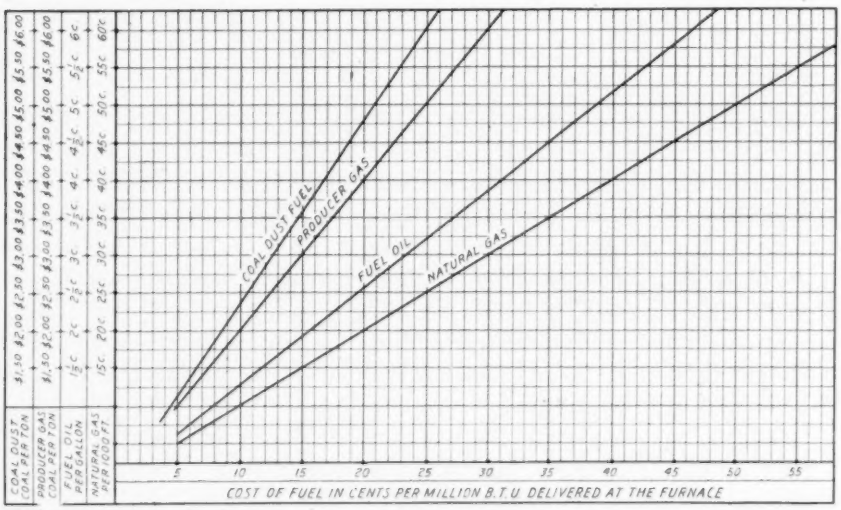

COAL DUST FUEL
PRODUCER GAS
FUEL OIL
NATURAL GAS
COAL DUST COAL PER TON
$1.50 $2.00 $2.50 $3.00 $3.50 $4.00 $4.50 $5.00 $5.50 $6.00
PRODUCER GAS COAL PER TON
$1.50 $2.00 $2.50 $3.00 $3.50 $4.00 $4.50 $5.00 $5.50 $6.00
FUEL OIL PER GALLON
1½c 2c 2½c 3c 3½c 4c 4½c 5c 5½c 6c
NATURAL GAS PER 1000 FT.
15c 20c 25c 30c 35c 40c 45c 50c 55c 60c
5 10 15 20 25 30 35 40 45 50 55
COST OF FUEL IN CENTS PER MILLION B.T.U. DELIVERED AT THE FURNACE

FIG. 1.

With recuperation, temperatures as high as 2200°C are possible. In the continuous kiln, temperatures up to 1400° are regularly obtained and 1500° is possible. Producer gas is used in burning German china, and such ware as Meissen and Dresden use a temperature of 1400° in glost firing.

Economy of Producer Gas

Producer gas, in the continuous kiln, or with recuperative furnaces, is the cheapest fuel today in most sections of the country and coal is the only fuel we know of that can be permanently relied upon. In some sections, near oil fields or oil refineries and remote from coal mines, oil is the cheapest fuel. The comparative cost of the different gaseous fuels and of coal dust firing is shown graphically on the chart. As coal dust firing is impractical on ceramic kilns, this need not be considered.

As the most practical and economical way of obtaining high temperatures with producer gas is in the compartment kiln, the advantages of this kiln in systematic control make it worthy of investigation by every member of this SOCIETY.

Conclusion

By reason of the past failures of producer gas firing in fire brick plants in this country, and in view of my own successful experience with this fuel, and from my belief that it is the fuel of the future, I have felt it my duty to bring the subject up for discussion by our Refractories Division. I want also to bring to the attention of our Committee on Research and Development, the desirability of further investigations of producer gas and gas producers, with the purpose of securing additional information on the best methods of operating gas producers for the application of heat to the ceramic industries. Practically all work done in this line by the U. S. Bureau of Mines has been in the use of producer gas for power by direct combustion in engines. There is much yet to be learned in regard to the generation and application of producer gas for heat. Such investigations would be impractical for the individual. No doubt much has been done in this line that has not been published or is not available to most of us. So, there is too much guess work and too much variation in the opinions of operators on many important points.

Yet, notwithstanding all this, gas producer operation is today a practical success and no one who gives the matter intelligent investigation need make any costly experiments. Knowledge is available to those who seek it and when once interest is aroused it will not be long before the burning of refractories with producer gas is as common in this country as in Europe and probably more successful, since we generally improve upon European equipment when we undertake to adapt it to our conditions.

COLUMBUS, OHIO

COLD CLEAN ARTIFICIAL GAS AND A DISCUSSION UPON THE GENERAL PROPERTIES OF GASEOUS FUELS[1]

By Alfred E. Blake

ABSTRACT

This paper[2] is written for the benefit of glass house people whose training has included no particular study of gas as a fuel. The advocation of some departure from the common practice, in the light of good and sufficient reasons, ought to be met in a receptive attitude. Warnings are given as to the acceptance of non-standard processes, and apparatus proposed by those of precarious financial backing and questionable familiarity with the technicalities of gas supply and application.

There is a brief survey of the field to be covered, followed by a discussion which shows how various gases may be classified. There is a pronounced difference in quality between the various kinds of producer gas, and other standard gases. The heat content per unit volume of theoretically perfect air-gas mixture is shown to be approximately equal for all high grade gases. This value plus the reaction temperature form two important considerations in the comparison of gas fuels. The importance of high "thermal head" in relation to rapid heating, and the economies of rapid heat transfer are pointed out. The fitness of high grade gas fuel for attainment of highest efficiency is shown. Theoretical flue gas heat losses are given.

A standard of 1,000,000 B.t.u. is proposed as a conversational basis for approximate comparison of gases as regards cost and volumes required. The merits of regeneration or recuperation are obvious for large scale, high temperature heating, but there are many reasons for adopting direct fire heating units for small operations. This emphasizes the value of high grade clean gas. The use of muffles in leers when clean sulphur-free gas is the fuel is ridiculous.

The cost of a method forms the general determining factor in selection when results to be gained are equal. Technical schools ought to give more training on the subjects of fuels and combustion. Apparatus, methods, materials, yields, properties, and application of coal gas, water gas, mixed coal and water gas, and coke producer gas to the glass industry are discussed briefly and illustrations are given. A table of comparison of these gases is given and is followed by the demonstration of the method of obtaining the results given.

Introduction

In starting to prepare a paper on cold clean artificial gases for the use of those interested in glass manufacture, it seems best to "prepare the soil" so to speak, for the reception of ideas which may be new to some.

Mr. Floyd W. Parsons, in an editorial,[3] makes the following statements:

Certain industries today continue to exist for no better reason than that they existed in the past. Certain practices continue to flourish although science has developed other methods to accomplish the same results more economically. Certain machines continue to be used in ever increasing numbers notwithstanding that other types have been perfected to do the same work at a lower cost.

[1] Presented before the Glass Division, Pittsburgh Meeting, February, 1923.

[2] This paper is destined for ultimate use as one of the chapters in a treatise on the Glass Industry, by Prof. Alexander Silverman, University of Pittsburgh, to be published by The Chemical Catalog Company, Inc. Its presentation here is by the courtesy of The Chemical Catalog Co.

[3] *Gas Age Record*, Dec. 24, 1921.

It is not possible to determine what should be by simply observing what is. One important fault of humanity is its tendency to be skeptical of all things new, rather than all things old. We would be better off if we were more critical of today's methods and more sympathetic concerning tomorrow's possibilities. The greatest cost in industry right now is ignorance.

These words of Mr. Parsons seem very eloquent to any one who devotes his time to the betterment of the art of heat supply.

Natural gas and fuel oil will ultimately disappear as glass house fuels. How soon this will happen may as well be left to the judgment of those who must choose fuels. The chief controlling factor will be the cost. In spite of certain practical and certain economic objections to it, producer gas seems to be popular as a glass house fuel. The great and increasing diversity of glass ware, affords many instances, however, where use of the best gas obtainable is justified. Furthemorer, many conceivable cases can exist where high grade gas is preferable, due to local conditions. The aim in this article is to set forth enough information to enable one to form a fair opinion as to whether any consideration of high quality gas is warranted. Inasmuch as the requirements for fuel in an optical glass factory differ from those in a bottle works, and the requirements in an art glass factory differ from those where oven ware or chemical ware is made, it is hoped that these views will not seem far-fetched to any who do not happen to be in touch with every phase of glass making.

The glass industry has been so favored in the past by cheap fuel of the highest quality, and portions of it are still so favored, that it is certain that a great percentage of glass men have never had any occasion until recently to give heed to the problems of fuel supply, and as evidence of this, very many costly mistakes have been made in trying to substitute one fuel for another.

It may take time to look into a fuel problem from all angles and to weigh all the arguments which are presented; but it is infinitely better to do so than to invite expensive failures by making snap decisions, not based upon sound technical facts. Oft times one can save much mental effort if he will simply consider the source of the information being given.

It is always safe to assume that those who are specialists in the gas industry are eager to secure any new process which has merit, and they are generally the first to learn of new developments or to develop new processes themselves. Many processes being offered industrial concerns today have already been very emphatically rejected by the leading gas engineering concerns.

Very likely a majority of glass manufacturers in natural gas territories hold the idea that producer gas is the only other gas besides natural gas; forgetting completely that whole towns, cities, and counties are being supplied with gas which is as suited in every way for glass making as

natural gas. The cost for city purposes is usually high, compared to natural gas prices, but such regions are generally long distances from coal and coke sources, and the distribution cost to domestic consumers is very considerable.

The number of gases to be considered is really quite small, and there are certain means for classification of gases as to fuel value which simplify matters still further. I propose to deal only with the ones which can be made by use of standard equipment and which involve no experimentation whatever. Any others which the reader may care to consider, as they may come up in the future, can be easily judged as to merit from the cases to be given.

Generalities in Technology of Gaseous Fuels

It is common to speak of the heat content of a gas and refer to the number of British thermal units per cubic foot which it contains, as though that were the final criterion for judging gas. It is not. In combustion, the air that is consumed is exactly as important as the gas. Water, electricity, steam, etc., are used as delivered; but gas must be supplied with air, or it is of no value as a source of heat supply. Owing to the different gaseous chemical substances composing various gas fuels, some take greatly different amounts of air than others.

Suppose we have 1 cubic foot of 1100 B.t.u. natural gas, which requires ten times its volume of air to insure complete combustion. We have:

	1 cu. ft. natural gas plus 10 cu. ft. air
Total	= 11 cu. ft. theoretical mixture

11 cubic feet of this mixture contains 1100 B.t.u. $\frac{1100}{11} = 100$; or each cu. ft. of mixture will liberate 100 B.t.u. when combustion takes place. Now consider blue water gas with a heating value, so called, of 300 B.t.u. per cubic foot. Each cubic foot of gas in this case requires 2 cubic feet of air, equaling 3 cu. ft. of mixture, which carries 300 B.t.u. $\frac{300}{3} = 100$, or each cubic foot of mixture will liberate 100 B.t.u., as in the case of natural gas. The air requirements in these two cases are stated approximately and for illustrative purposes. To carry the case out for producer gas, we have, let us say, a 150 B.t.u. gas, and 1 cu. ft. requires 1.7 cubic feet of air for complete combustion. The mixture which would have 150 B.t.u. would be 1.7 + 1 or 2.7 cubic feet. $\frac{150}{2.7} = 56$, or a cubic foot of mixture has 56 B.t.u.

If other factors were equal, one would surmise that the matter of equal heat delivery resolves itself into getting the heat units into the field of action at the same rate in any case. This would mean that $\frac{1100}{300}$ or $3^2/_3$ times as great a volume of blue water gas would have to be burned in place of one volume of natural gas or that $\frac{1100}{150}$ or $7^1/_3$ times as much producer gas would have to be used in place of natural gas. This would hold except for the fact that gases do not all burn with equal speed or intensity. This is due to their varying makeup. Practically all of the natural gas from eastern fields is 100% combustible. Blue gas is about 91% combustible; but its combustible components, hydrogen and carbon monoxide, burn with great speed, whereas natural gas, being chiefly methane, CH_4, is quite slow burning. Methane must undergo decomposition before its carbon and hydrogen can oxidize, and the decomposition requires both time and some of the heat which would otherwise be available. Coal gas and by-product coke oven gas, with their large percentages of hydrogen, each burn faster than natural gas.

Combining the foregoing with the statements in the preceding paragraph as to air requirements, another angle to the subject suggests itself. Whether the fuel is natural gas or blue water gas, it seems that the volume of air plus the volume of gas necessary to supply 100 B.t.u. is a constant quantity, namely 1 cubic foot. Therefore, while in one case we are using three times the volume of gas as in the other, it turns out not to be a fact of the slightest importance so far as delivering heat in proper concentrated form to the furnace goes. As to producer gas, however, we have a case comparable to such an instance as the following: One solution of sulphuric acid and water is 25% acid by weight. Another solution is 50% acid by weight. The amount of each solution is such that the same weight of acid is contained in each. Naturally, the 50% solution has less water and may be expected to dissolve a batch of metal more rapidly than the 25% solution. In this case, the excess water is comparable to the high percentage of non-combustible nitrogen and carbon dioxide always to be found in producer gas. From the statements already given, the ratio of concentration of heat units from the use of natural gas or blue gas to the concentration of heat units from use of bituminous producer gas is about 100: 56.

It is evident, therefore, that 1000 B.t.u. of natural gas, or of blue water gas or of producer gas are not equal in heating value. We find by definition that a B.t.u. is that quantity of heat which will increase the temperature of one pound of water 1°F. The establishment of such a heat unit does not enable us to compare the merits of gases directly. If heat

must be transferred at the temperature of 2700°F it is very important to be sure that the gas to be used will enable that temperature to be maintained *without undue waste.*

A water fall is a source of mechanical energy. The higher the fall, the greater the "head of water" obtainable in harnessing it for service, consequently the greater the available energy. Fuel engineers have coined the term, "Thermal head." The analogy is obvious. One of the laws of thermo dynamics states that the greater the difference in temperature between two bodies placed in contact, the more rapidly will the coolest of the two absorb heat from the other. "Thermal head" simply means a difference in temperature. When heating glass with gas, the heat transfer is from gaseous products of combustion to solid or liquid. The hotter the products of combustion, the faster the heating.

Some gases when burning, liberate products of combustion at much higher temperatures than others do. This is one of the chief reasons why one gas fuel is better than another. In order to have a basis for comparing gases in this very important respect, one may calculate the temperature which would be reached by the products of combustion if all the heat liberated in reaction were applied to heating these products only. The calculation is a difficult and tedious one and the result is purely theoretical. It is commonly spoken of as "theoretical flame temperature," although it is more proper to refer to it as the "theoretical reaction (or combustion) temperature." This temperature, correctly calculated, is a very important item among the properties of gas fuels commonly mentioned. By use of it, we can judge the "thermal head" to be expected by use of a gas. Even when a quantitative or perfect theoretical mixture of gas and air is burned, the theoretical reaction temperature is not attained, owing to heat losses by radiation of light wave energy, and partial dissociation of some of the gases involved.

It happens to be a fact that these theoretical reaction temperatures for the high grade gases run very close together. They vary with the composition of each particular gas; but in general, natural gas yields the value of about 3370°F; blue water gas 3470°F; coal gas 3300°F to 3450°F; by-product oven gas 3300° to 3400°F. For practical purposes, I consider them all as being equal.

The case of producer gas is different from the others, however. Depending upon its composition, such gas will range in reaction temperature from 2400°F to 2900°F. The reader will be able to understand why the French term for producer gas means "poor gas." (*Gas pauvre.*)

We are in position now to answer the question about the relative value of heat units from one source or another. Suppose we wish to maintain a furnace interior and its contents at the temperature of 2500°F using a producer gas which can yield, theoretically at least, combustion products

at 2800°F. The amount of heat hich wthe combustion gases, and inert gases, can yield to the furnace and batch is that which is necessary to give them the temperature of 2800°F minus that which is necessary to give them the temperature of 2500°F, or the amount required to make a difference of 300°F. Therefore, the thermal head is 300°F. The rate of heat transfer will have a certain definite value.

Suppose instead of producer gas we use a gas having a reaction temperature of 3450°F. Then the thermal head will be 3450–2500 or 950°F, and the rate of heat transfer will be proportionately higher than in the case first given. The work to be heated will *be able to absorb a higher percentage of the heat liberated;* in other words, higher thermal efficiency will be secured from 1,000,000 B.t.u. of natural gas than from the same number of heat units supplied as producer gas.

When the heat transfer is rapid, less heat has a chance to be carried into the flue, or through the roof or walls of the furnace.[1] To make this a little clearer we may say that good furnace practice is such that the temperature at the flue hole in a furnace is about 200°F higher than the temperature of the material being heated. In each case given above, therefore, the thermal head, or effective drop, is 100°F and 750°F, respectively.[2]

We must emphasize the fact that we are not concerned merely with the quantity of heat units we have to deal with, but we are interested also in knowing what the form is; whether as a gas which enables one to secure a good thermal head, or rapid heat transfer; or as gas which will not even approach the furnace temperature required.

If either of two gases can be used to do a given piece of work, then the problem may be chiefly financial, since cheapness may often overrule thermal efficiency. Few glass concerns have means for knowing surely what the comparative possibilities of two gases may be when applied to a particular piece of work. Here is another instance where the cost of expert advice may be well justified.

Fig. 1 is a plot which shows conveniently just what the flue heat loss is for each of several gases, when their products of combustion leave at a stated temperature. The data has been made up by assuming the use of the theoretical amounts of air for complete combustion for each gas, and determining the weight of each constituent of the flue gas, per unit of fuel, for use with the various specific heats in determining the sensible heat for

[1] Unless expressly stated otherwise, these cases which are cited relate to direct firing only.

[2] Furnace practice and furnace design are so important as factors that it is difficult to write the present discussion without more mention of furnaces. In the two cases given here, it is assumed that the reader will realize that merely to produce such a parallel, furnaces of different design would be necessary. As a matter of fact, the cold producer gas could hardly be used with air for securing the temperature of 2500°F, and it is never to be recommended for *efficient* work above 1700° or 1800°F.

various temperatures. In other words, the figure shows at a glance what percentage of heat generated is carried away by the flue to waste for any given flue gas temperature.

From the foregoing, one can see that to simplify our expressions with regard to various gases of different thermal qualities, we should make some kind of generalization to be used in ordinary discussion. This can be done very conveniently. Most glass house men have been accustomed to think in terms of natural gas, and in thousands of cubic feet of it. The price per thousand is a figure easily retained for comparative purposes. Natural gas after thorough stripping for motor fuel, etc., contains about 1000 B.t.u. per cu. ft. Therefore, 1000 cu. ft. contains 1,000,000 B.t.u. Then

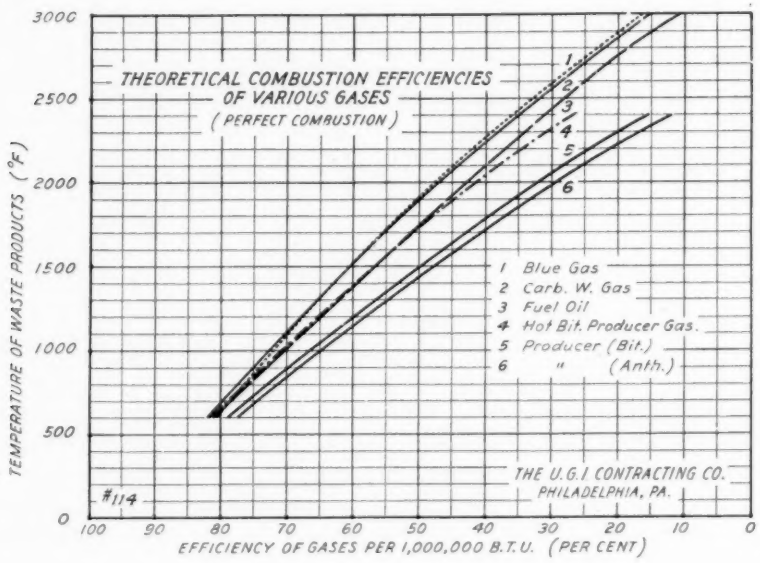


FIG. 1.

the price of 1000 cu. ft. is the same as the price for 1,000,000 B.t.u. It is also fortunate that natural gas is one of those which has a high theoretical reaction temperature; so that all things considered, it forms a fairly satisfactory standard of heating value for high grade gas fuels.

To duplicate the heating effect of any given amount of natural gas by the use of some other *high grade* gas, we have seen that it is necessary to furnish the latter in volume sufficient to carry the required heat units. Little else matters, if the combustion is to be controlled by modern equipment. In any discussion about costs, it is a very simple matter, therefore, to speak in terms of thousands of cubic feet of natural gas, or better, in terms of millions of B.t.u. When this is done, confusion is eliminated,

and direct practical comparisons can be made as closely as the present state of the art of heating on a large commercial scale warrants their being made.

The foregoing considerations have been based upon direct firing practice, that is, by use of cold air and cold gas, with no preheating. In large furnaces, where high temperatures are required, direct firing is so wasteful that none but the most benighted are continuing the practice. With cold producer gas, high temperatures simply cannot be secured by direct firing, as stated before. If any method of preheating will make a useless gas useful, so much the greater reason for preheating when high grade gas is used.

There are many heating operations required in various instances of glass making which call for numbers of small furnaces, and for furnaces which have never yet been designed for any other fuel than gas. The temperature required may be high, as in sealing, softening, polishing, cutting, etc., or low, as for annealing; but whether one or the other, the size of furnaces must be kept as small as possible to save factory space. High quality gas is justified here even at a cost greatly in excess of any substitute. High quality gas will give the temperature desired without recourse to preheating. It is handled with great ease, with the smallest possible sizes of pipe, and the control of firing can be automatic and perfect. It can be supplied perfectly clean and free from sulphur, tar, dust, and other matter which might be injurious to quality.

Another consideration favoring clean high grade gas is that found in the elimination of muffles or semi-muffles. Good firing practice has proven these to be entirely unnecessary for the protection of the ware when clean gas free from sulphur is used, as all glass men know who have used natural gas. High grade gas can easily compete with "cheap," (?) dirty gas by the elimination of muffles. This is because of the necessity for using vastly more heat in a muffle furnace in order to secure the desired temperature in the ware. The interposition of the muffle between combustion zone and ware cuts off contact between the ware and combustion products which carry the heat. Instead, the heat must pass through the muffle wall, which generally consists of clay or material containing carborundum, in order to heat air which will pass the heat finally to the ware. Far greater thermal heads are necessary in muffle heating. This is in spite of the very clever and attractive appearing muffles which are offered.

The fact must be recognized that ways can be found for making an excellent product with the poorest fuels. If these methods will stand the economic tests, meeting competition, and prove to be the most profitable to the investors, little remains to be said for the use of different methods and materials. It will behoove every management to spare no pains in these days, however, to investigate the offerings of *going concerns* who have *standard equipment* which can be adapted for glass house use.

It is regrettable that technical institutions which aim to train men for glass house and ceramic engineering are generally so backward in the matter of giving adequate instruction in the technology of fuels and combustion, and that such matters are generally handled through the departments of Mechanical Engineering as though they had no relation to chemical practice.

Standard Gases

A. Coal Gas (Also By-Product Coke Oven Gas).—Coal gas is evolved in the destructive distillation of bituminous coal. Ovens of various sizes and shapes, built of clay, or preferably of silica ware, are employed. These in general have one long dimension, which may be horizontal or vertical. Appropriate means are employed for heating the retorts continuously, and coal is generally charged in batches, intermittently. The heating may be accomplished by the use of part of the coal gas made; or producer gas, preferably made from coke screenings, can be used. Recuperation or regeneration of heat should be practiced by preheating the air used for combustion. High volatile coals are preferable. Twenty-nine per cent to 38% volatile combustible matter represents the usual limits. Depending upon the numerous factors involved, the total gas yield is from 9000 to 13,000 cubic feet per net ton. The calorific value of coal gas can vary with conditions between 450 and 650 B.t.u. per cubic foot. A fair figure for the yield of heat units as gas per ton of coal would be 6,400,000 B.t.u. If coal gas is used to heat the ovens, about 40% of the total make is required, and all of the small coke (breeze), with additional fuel, will be required for boiler fuel in supplying the steam necessary to operate the various plant accessories. If the small coke is used to make producer gas, all of the coal gas can be sent out, and waste heat boilers can be interposed at suitable points to recover heat and furnish all the steam needed.

In addition to gas, coke, tar, light oils, ammonia, and other residuals are made in sufficient quantities that their total market value should exceed the operating cost by at least a small margin. It would interest glass melters to know that the tar is at least as valuable as oil for fuel. Good average practice with vertical retorts will show a yield of from 12 to 14 gallons of tar which is very fluid and a suitable oil substitute. By such use, nearly 2,000,000 more heat units can be had per ton of coal.

Coal tar is removed from gas with ease; so that the gas can be completely purified, if desired. Two constituents of coal gas which are objectionable for glass finishing work are hydrogen sulphide and carbon disulphide. These have no influence in melting except to furnish additional heat. The first named may be present in quantity up to 800 grains per 1000 cubic feet; 600 grains would be common. It is possible, however, to remove it to leave the merest trace, or 2 grains per 100 cubic feet. Carbon

disulphide occurs in smaller quantities (10–50) grains per 100 cubic feet, but it is much harder to remove. A very efficient process for doing this exists, however.

Following is a typical analysis for coal gas (*a*) and one for by-product coke oven gas (*b*).

(*a*)		(*b*)	
Carbon dioxide (CO_2)	2.6	Carbon dioxide (CO_2)	2.1
Illuminants	3.2	Illuminants	2.0
Oxygen (O_2)	0.2	Oxygen (O_2)	0.3
Carbon monoxide (CO)	6.4	Carbon monoxide	6.0
Hydrogen (H_2)	46.8	Hydrogen (H_2)	57.0
Methane (CH_4)	35.4	Methane (CH_4)	27.0
Nitrogen (N_2)	5.4	Nitrogen (N_2)	5.6
B.t.u. per cu. ft.	605	B.t.u. per cu. ft.	528
Specific gravity	.42	Specific gravity	.38
Theoretical reaction temperature	3407°F	Theoretical reaction temperature	3407°F

The foregoing remarks have been made general enough, purposely, so that they will serve to cover by-product coke oven gas. The latter generally does not have as high a calorific value as coal gas, but otherwise no important differences exist. By-product coke ovens do not yield as great a return in gas heat units, or in tar and ammonia as vertical retorts, and they have their greatest field in the production of metallurgical coke. They are very costly when considered only for small requirements.

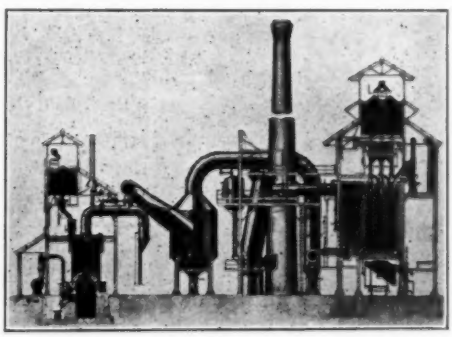


FIG. 2.—The U. G. I. intermittent vertical retort system with detached producer and waste heat boiler. The U. G. I. Contracting Company.

Coal gas and by-product oven gas have been used for years for glass making and finishing. The writer knows of no instance in the past, however, in which the gas was not purchased by the glass people. Except as an adjunct to a complete gasification plant, a coal gas plant would be too costly and complicated an investment for a glass concern. Probably the hardest problem would be in the regular and profitable disposal of coke. Under another heading, coke disposal will be discussed further.

The accompanying illustration shows, in section, a modern retort plant, including retorts, housing, foundations, coal and coke handling equipment, producer house, with breeze producer, bin, blower, gas main, cyclone dust

arrester, dust legs, and method of recuperation; also waste heat boiler, drum, stack, etc.

The retorts are built in benches of nine. Seven benches constitute a battery. One producer will serve each battery. When a plant having less than seven benches is required, the producers are built in conjunction with the retorts. Normal duty for each retort is the carbonization of 2.2 net tons of coal per 24 hours. All steam requirements, for producers, blowers, exhausters, fans, etc. are met by the boiler.

Water Gas.—Two kinds of water gas are standard. The term water gas is usually taken to imply carburetted water gas. Carburetted water gas is made by cracking oil in an atmosphere of blue water gas. The oil vapors serve to enrich the blue gas by the addition of hydrocarbons, especially those which cause flame luminosity. 2.65 gallons of oil per thousand cubic feet of finished gas will give a product having about 550 B.t.u. per cubic foot. The gas is used chiefly for domestic and commercial purposes, but it is used industrially also, when the application is such that the usual high cost is overbalanced by higher efficiency, increased production, and higher quality of production.

Carburetted water gas is as well suited for glass house use as coal gas or natural gas, and there have been many applications. No glass concern would be warranted in owning a carburetted water gas plant, in the writer's opinion. The future for oil is too uncertain, and it is an unnecessary material, as may be seen.

Blue water gas, so called because of its blue flame, which is due to the large content of carbon monoxide, also known as straight water gas, or uncarburetted water gas, is made by the intermittent action of steam upon incandescent carbon, which is heated once each cycle of operations by blasting with air. A typical cycle would have a blasting period of one minute, an upward steaming or "run" of one minute and a downward steaming of one minute. The coke, or anthracite coal, is held upon a grate in a brick-lined insulated generator, suitably connected with air, steam, gas piping, valves, etc. The best practice includes automatic control apparatus for operating the valves and ensures results which are uniform, with a minimum of supervision. All but the smallest blue gas generators should be provided with waste heat boilers, with which all steam required can be made from the heat in the blast gases and the water gas. The generators are built in sizes which have standard ratings from 2,000,000 B.t.u. to 26,000,000 B.t.u. per hour, as blue gas, or from 4 feet to 12 feet outside diameter.

The accompanying illustrations show a small blue gas generator, with accessories, in section, with grate, coke charge, valves, seals, piping, stack, etc. in view; also a larger set, showing in addition to the features mentioned, automatic control, waste heat boiler, etc.

The object in blasting with air is the production of heat in the charge by the action of oxygen upon a portion of the carbon. Blasting is conducted at high pressure and the greater the CO_2 content of the blast gases (really lean producer gas) the greater the heat liberated in the charge per pound of carbon gasified. In general, the blast gases may have only

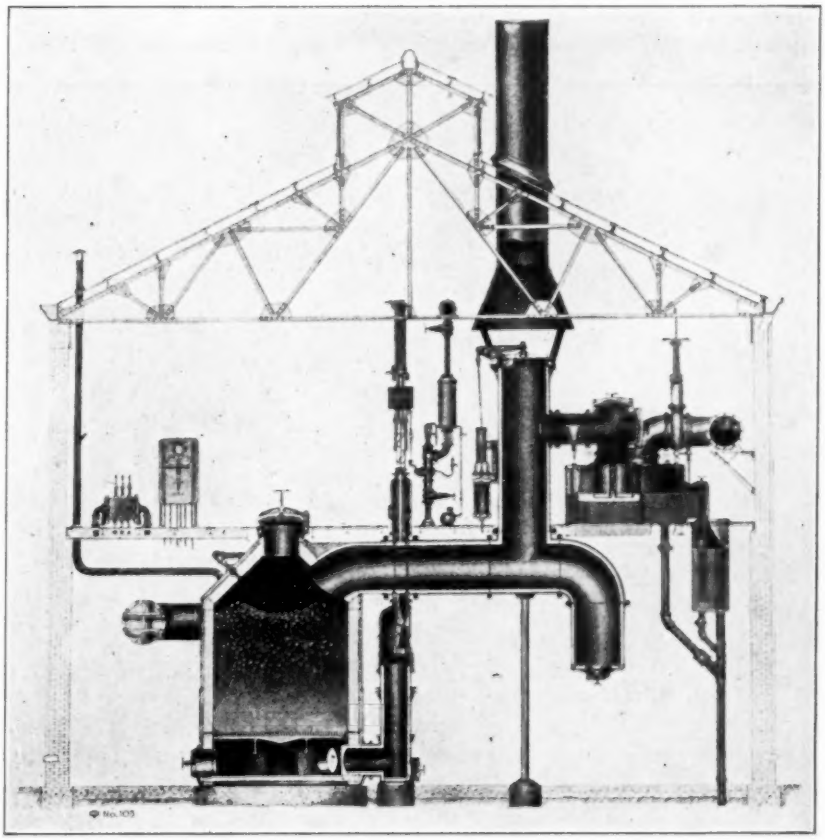


FIG. 3.—The U. G. I. blue gas apparatus (cross-section). The U. G. I. Contracting Company

about 10% CO. High pressure blasting enables the length of blasting period to be shortened to a minimum.

It is necessary for the charge to be well and uniformly heated when steam is to be applied, to such an extent that a maximum steaming period can be secured. The reaction of steam upon hot carbon is endothermic, that is, it requires an external heat supply and a working temperature above a certain minimum, or the desired results will not be forthcoming.

The desired result of steaming is shown by this chemical reaction:

$$H_2O + C = H_2 + CO$$

If the temperature of the charge becomes too low, however, the reaction becomes:

$$2H_2O + C = 2H_2 + CO_2$$

which is undesirable. It can be seen that the process is simply a cycle designed to take the best advantage of the thermo-chemical behavior of

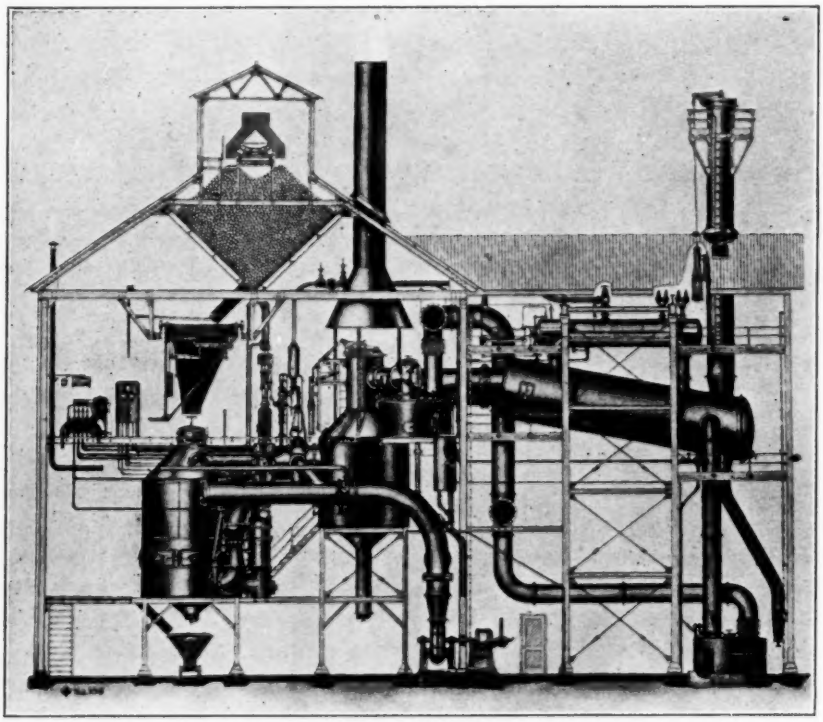


FIG. 4.—The U. G. I. blue gas apparatus with waste heat boiler. The U. G. I. Contracting Company.

steam and carbon. With automatic valve operation, accurately timed, and the use of waste heat boilers, the thermal efficiency of the process will be from 65 to 70%, or equal to very many producer gas operations, with the added advantage of vastly superior quality of gas resulting.

Blue gas, like producer gas, is poisonous, because of its carbon monoxide content, but as a warning against leakage, it is a very simple and inexpensive matter to give it an odor by means of which it can be detected promptly. Phenyl-isocyanide, one of the stenches of chemical warfare has been used with satisfaction.

Any number of generators can be installed in a plant in order to have the desired capacity and operating features. Spare sets should be included, whenever continuous operation is desired, since a generator grate should be cleared of ash and cinder about once in eight hours. Large generators can be built in pairs, to use a common waste heat boiler. In order to insure a steady gas supply, a holder must be used as a temporary storage space for gas. Its size will depend upon operating conditions.

Following are analyses of carburetted water gas and blue gas.

Carburetted Water Gas		Blue Gas	
Illuminants	10.7%	Carbon monoxide (CO)	43.5%
Carbon monoxide (CO)	33.4	Hydrogen (H_2)	47.3
Hydrogen (H_2)	38.1	Methane (CH_4)	0.7
Methane (CH_4)	7.6	Carbon dioxide (CO_2)	3.5
Ethane (C_2H_6)	2.4	Oxygen (O_2)	0.6
Carbon dioxide (CO_2)	3.3	Nitrogen (N_2)	4.4
Oxygen (O_2)	0.7		100.0%
Nitrogen (N_2)	3.8	Specific gravity	0.559
	100.0%	Calorific value	302 B.t.u.
Specific gravity	0.676	Reaction temperature (calc.)	3470°F
Calorific value	602 B.t.u.	Specific heat	.45

Blue gas has been demonstrated as superior to carburetted water gas, coal gas, and mixtures of these, for many manufacturing purposes. This is especially true in the incandescent lamp industry where highly developed apparatus for cutting and sealing is used. It is an ideal gas when purified, for annealing, polishing, heating glory holes, decorating ovens, and enameling.

The cost of blue gas when high grade equipment is used, depends chiefly upon the cost of coke, or anthracite coal, but also upon the requirements of the factory which is to be served. For instance, a 24-hour demand will enable a much cheaper production than 8- or 10-hour demands. Except for *small installations*, or in cases where the glass factory can obtain a supply of cheap coke or anthracite, blue gas plants by themselves are not likely to become frequent in the glass industry. Where the value of a glass product is high, and no great quantities of gas are called for, but a high temperature is essential, as in cutting, sealing, decorating, polishing, and the like, the use of blue gas should have careful consideration. When the proper modifications to blue gas apparatus have been perfected to permit the substitution of bituminous coal for coke, the use of blue gas in glass manufacture will immediately command the attention of all glass makers. A development of this sort can be looked upon as the next logical step in the design of industrial gas apparatus. Many interesting attempts have already been made along this line. For years past, much carefully worded printed matter has been available, gotten up to show how simply

the problem can be solved, and promoters with little financial standing have been ready to promise whatever might be satisfactory to the prospect.

Complete Gasification of Bituminous Coal to High Grade Gas

We know that the coke from a coal gas plant can be gasified with ease, either to make blue water gas or clean producer gas. Each process is a standard one which has been used for many years. Making coal gas and purifying it involves no difficulty whatever. The same is true for blue gas and coke producer gas. Complete *two-stage* gasification consists simply in building a coal gas plant and a blue gas plant side by side, or in certain cases, the work to be handled might enable the substitution of coke producers for blue gas sets. The coal gas plant would supply coke for blue gas or producer gas. The 600 B.t.u. coal gas would be mixed in the same holder with the 300 B.t.u. blue gas to yield gas of about 375 to 400 B.t.u. per cu. ft., the calorific value depending upon the coal used. If the coke is used for making producer gas instead of blue gas, it would be poor practice to mix the two, because too large a holder would be necessary for proper mixing, and because such a producer gas section can be made so automatic in its operation as to require no holder whatever. This would permit of using coal gas and tar for heavy melting operations and producer gas for annealing and other comparatively low temperature work. The producer gas from coke can be made cool and clean, hot and clean, or hot and containing dust. The selection would depend upon requirem ents and upon the nearness of the gas plant to the factory. One ton of coke would yield about 150,000 cu. ft. of 128 B.t.u. gas. The cut which illustrates the section of a coal gas plant shows the type of producer in mind, with cyclone dust arrester and fittings for making hot clean gas (1020°F) for heating coal gas benches.

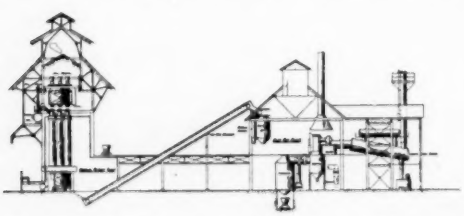


FIG. 5.—U. G. I. combined coal and blue gas plant.

The following illustration is a sketch outlining a complete gasification plant, in which is shown the retort plant (which is integral with the producers in this case), conveyor for hot coke, hot coke screen, insulated bins for the lump and fine coke, lorry car for supplying the producer with fine coke, blue water gas section, etc.

Nothing novel is involved at any stage of the complete gasification process illustrated above. Every operation is one which has been standard practice for many years.

The total cost of gas made by this two stage process, including investment charges enables very close competition with natural gas in such localities as Western Pennsylvania and Ohio, where good low cost coal is available, and the cost for natural gas is being advanced. With coal delivered at $3.00 per net ton, a fair sized plant will make mixed gas at costs ranging from $.35 to $.40 per million B.t.u. depending upon size of plant, quality of coal, factory demand characteristics and other conditions.

Other Gases

1. Clean Producer Gas from Bituminous Coal.—Numerous interesting attempts have been made to clean bituminous producer gas, some of which have had a measure of success. Not only is such gas exceedingly difficult to make entirely free from tar, but the tar which is recovered amounts to from ten to sixteen gallons per ton, and is invariably so impregnated with water, ash and carbon, and is so viscous, as to be not only worthless, but it constitutes a liability, in that it is most difficult to dispose of. No satisfactory solution has come to the writer's notice thus far. The cleaning processes used do not remove sulphur compounds; so that furnace provisions must be in accord with that fact. A muffle leer heated with cold producer gas would be about as inefficient a piece of combustion engineering as one can imagine. The loss of combustible material as tar amounts to from 1,500,000 to 2,200,000 B.t.u. per ton of coal gasified; an additional source of inefficiency as regards the adoption of this sort of producer gas.

2. Coke Producer Gas (Also Anthracite Producer Gas).—Coke makes excellent producer gas, which *carries no tar* and which, therefore, is easily cleaned. A good sample of such gas would have about 128 B.t.u., contain about 12½% hydrogen and 27% carbon monoxide. Its theoretical air-gas mixture would contain about 65 B.t.u. per cubic foot.

In addition to the high pressure type of coke producer shown in Fig. 2 are numerous makes of suction producers ranging in capacity from 300,000 B.t.u. in gas, to 9,000,000 B.t.u. per hour. Their capacity for unit grate area is very low, but they are of some utility where demand is low and variable. One general application for them is in the operation of gas engines for power purposes. The gas can be conveniently purified, however, for use in low temperature work. Whenever small coke or anthracite screenings can be had at low cost, it may be found profitable to look into the possibilities for its application in certain glass work, where the demand for gas is very small indeed.

3. Producer gas can be made from oil, which, in appropriate apparatus, will yield gas of heating values from 400 to 600 B.t.u., and with reaction temperatures as high as that of natural gas. It is necessary to use oils which are *non-coking*, however, and these are not only difficult to secure

in dependable supply, but their cost makes the use of the process prohibitive for any but the most special cases and localities where coal and coke are dear, and oil is cheap, as in the far west.

General

No gases not mentioned in the foregoing are standard as yet for industrial fuel uses. Doubtless new processes will be developed which will have great merit. In entertaining the use of any sort of artificial gas, however, whether it is standard or not, money, time, annoyance, and disappointment can be avoided if the management will seek the advice and services of concerns which are obviously competent in the field of gas and combustion engineering. For double protection, every progressive concern, bent upon eliminating mistakes and waste, should employ at least one man who is trained and experienced in the company's fuel problems in whom they can place confidence, and who can translate to them the merits of every proposal for the solution of fuel problems.

As the glass industry is still emerging from craft to a scientific basis, many opinions upon fuel and furnace practice are founded on what is akin to superstition, derived from the old rule of thumb methods and imported to this country with our various branches of industry before any transition had begun. If the facts and ideas given here are stated clearly enough to demonstrate how reasonable they are, the writer's object is accomplished.

In closing, and for the sake of exactness, it seems well to include the following table, which will be found specific instead of general, and which will show the precise results of comparative study upon the few gases named. In securing these it has been found of great advantage to use the volume reactions for the oxidation of the gases present. Following the table are two examples which show the method of working for natural gas and for blue gas.

COMBUSTION DATA ON BLUE WATER GAS

ANALYSIS OF GAS:

CO	= 43.5%	Sp. gr. = .559
H_2	= 47.3	Sp. ht. = .45
CH_4	= 0.7	Heat content = 302 B.t.u.
CO_2	= 3.5	Reaction temperature (theoretical) = 3470°F
O_2	= 0.6	(Note: O_2 in air taken as 20.9% by vol.)
N_2	= 4.4	
	100.0%	

$$\underset{(.435)}{2CO} + \underset{\substack{(.2175)\\(1.0407\ Air)}}{O_2} = \underset{(.435)}{2CO_2} \qquad \underset{(.473)}{2H_2} + \underset{\substack{(.2365)\\(1.1316\ Air)}}{O_2} = \underset{(.473)}{2H_2O}$$

$$\underset{(.007)}{CH_4} + \underset{(0.14)\ (.067\ Air)}{2O_2} = \underset{(.007)}{CO_2} + \underset{(.014)}{2H_2O}$$

1.0407
1.1316
.0670

2.2393 Gross vol. air to burn 1 vol. gas.

Correction for oxygen content in blue gas. (.6% O_2 = .006 volumes, equivalent to .0287 volumes of air.)

2.2393
0.287

2.2106, Net volume of air to burn 1 volume gas.

2.2106 + 1 = 3.2106 cu. ft. of theoretical mixture per 1 cu. ft. gas.

$\frac{302}{3.2106}$ = 94.06 B.t.u. per cu. ft. theoretical air gas mixture.

Products of Combustion:

a.	CO_2	in gas	.035	
		from CO	.435	
		from CH_4	.007	.477
b.	H_2O	from H_2	.473	
		from CH_4	.014	.487
c.	N_2	in air	1.748	
		in gas	.044	1.792
d.	O_2	in gas	.006	.006
				2.762 Cu. ft. per cu. ft. gas.

$\frac{302}{2.762}$ = 109.34 B.t.u. per cu. ft. products of combustion.

$\frac{.487}{2.762}$ = .1763 or 17.6% H_2O in products of combustion.

Combustion Data on Natural Gas

Analysis:

CH_4	=	84.0%
C_2H_6	=	15.8
CO_2	=	0.2
		100.0%

Specific gravity .631
B.t.u. 1126

$$\underset{(.84)}{CH_4} + \underset{(1.68)\ (8.038\ Air)}{2O_2} = \underset{(.84)}{CO_2} + \underset{(1.68)}{2H_2O}$$

COMBUSTION DATA ON NATURAL GAS (*continued*)

$$\underset{(.158)}{2C_2H_6} + \underset{\substack{(.553)\\(2.646\ \text{Air})}}{7O_2} = \underset{(.316)}{4CO_2} + \underset{(.474)}{6H_2O}$$

8.038
2.646

10.684 Vols. air required to burn 1 vol. gas.

10.684 + 1 = 11.684 cu. ft. of theoretical mixture per cu. ft. gas.

$\frac{1126}{11.684}$ = 96.37 B.t.u. per cu. ft. of theoretical air-gas mixture.

Products of Combustion.

a.	CO_2	in gas	0.200	
		from CH_4	.840	
		from C_2H_6	.316	1.356
b.	H_2O	from CH_4	1.680	
		from C_2H_6	.474	2.154
c.	N_2	in air	8.451	8.451
				11.961 cu. ft.

Products of combustion per cu. ft. gas.

$\frac{1126}{11.961}$ = 94.14 B.t.u. per cu. ft. of products of combustion.

$\frac{2.154}{11.961}$ = .1801 or 18.01% H_2O in products of combustion.

Comparison of	Natural gas	Blue gas	Cold clean coke producer gas
B.t.u. per cu. ft.	1126	302	128.5
No. cu. ft. air for theoretical combustion	10.684	2.21	.938
B.t.u. per cu. ft. theoretical air-gas mixture	96.37	94.06	66.3
No. cu. ft. flue gas per cu. ft. gas from theoretical air-gas mixture	11.961	2.762	1.743
B.t.u. per cu. ft. flue gas	94.14	109.3	73.6
Per cent H_2O in flue gas	18.01	17.6	7.16
Cubic feet per million B.t.u.	888.1	3311.0	7775.0
Reaction temperature	3370°F (?)	3470°F	2730°F

O_2 in atmosphere = 20.9% by vol.

Discussion

G. FITZGERALD:—What is the size of the smallest generator which can be had?

A. E. BLAKE:—You can have a standard generator 4′ in diameter which is rated to furnish 2,000,000 B.t.u. of blue gas per hour. The sizes of standard generators increase by a foot in diameter, the largest having a diameter of 12′ and a rated hourly capacity of 37,500,000 B.t.u. of blue gas.

W. W. OAKLEY:—What is the advisability of large holders and where is the economical point reached as to the advisability of putting in duplicate generator equipment?

A. E. BLAKE:—There must be a holder in any case. The situation is very simple when there is a steady 24-hour demand for gas or even when the working day is 10 hours, but the demand is steady. It is impossible to do without a relief holder at least, on account of the intermittent way in which the gas is made. If a single generator is used the holder must have sufficient capacity to supply the demand for gas during the period occurring about every 8 hours when the grate of the generator must be cleaned. This period may be from 30 minutes to 2 hours, depending upon the size of the generator and other conditions. Hence the advisability of having two generators, each of which may be a standby set in turn. The normal rating of such an installation would be that of a single generator, but it furnishes a much more satisfactory operating condition and it is possible to fit the installation to the demand characteristics for gas more nicely. For instance, when the hourly demand throughout an ordinary day is at a given figure which might correspond to the rating of one generator, there may be times during the day, or during the week, say in the morning, when furnaces are being started up, and after a noonday period, or other periods constituting daily shifts in plant operation, the demand for gas may easily be doubled for perhaps an hour, when the operators are bringing their furnaces up to the working temperature. At such times, and for any other emergency, it is a simple matter to throw in the standby generator and have a temporary 100% additional production.

A MEMBER:—What means are there for eliminating the sulphur in blue water gas?

A. E. BLAKE:—The elimination of sulphur is an important item if gas is to be used in a direct-fired leer, or in any other application where the glassware can receive a frosted coating which is objectionable. Sulphur has been very thoroughly removed from illuminating gas in all our large cities where it is used, for a very long time, at least for 40 or 50 years. There are numerous acts and ordinances in the various states, counties and cities regulating the permissible sulphur content of artificial gas for domestic use. If sulphur were not removed household furnishings which have been dyed, such as draperies, wall paper, etc. would in time become bleached from the action of sulphur dioxide produced in the burning of the gas. The presence of sulphur would also be noticeable by the odor of the sulphur dioxide. You will see how important it is to thoroughly purify artificial gas in order to remove these serious objections, and therefore, you can surmise that the state of the art of gas purification has been developed to a high degree of efficiency. Blue water gas lends itself with ease to all methods of purification which are known. The commonest

method in use consists of passing the gas after scrubbing and cooling through a box in which is a series of trays, loaded with a mixture of iron oxide and shavings. At the start iron turnings can be taken, which after use are oxidized. Such an arrangement will serve to purify the gas for a very considerable period before it is necessary to replace the material with a fresh supply and permit the spent mixture to revivify by exposure for a time to the air. If it is desirable or necessary the sulphur content of any clean artificial gas can be reduced to the order of a *trace* of sulphur.

W. W. OAKLEY:—What capacity of holder would be required for a blue gas plant consisting of 2 to 4 foot generators?

A. E. BLAKE:—Depending upon the conditions of operation I would say the holder should be of 20 or 25 thousand cubic feet capacity. If storage would be desirable it might be advisable to install a 50,000 cubic feet holder, but that would be large for a plant of such size.

W. W. OAKLEY:—Would you run both sets?

A. E. BLAKE:—Both sets can be run part of the time, but each one must be shut down for cleaning after each 8 hours or so of steady operation. For so small a set, only about 20 minutes would be required for cleaning. In determining the size of an installation, however, it is essential to choose in such a way that there is always to be a comfortable margin of production capacity, or holder capacity, in order that every reasonable call for gas can be promptly met. When the operation is for 8 or 10 hours it is often advisable to install more holder capacity in place of spare generators for the reason that holder capacity is cheaper than generating capacity and since holders are simple compared to generating equipment the general expense for upkeep can be lowered. It is possible, however, and practical to keep two generators constantly under fire while one acts as a reserve ready at a minute's notice to be called into play.

A. MEMBER:—Can blue water gas be used directly from the holder under holder pressure, or is it necessary to install additional apparatus?

A. E. BLAKE:—The holder throws a pressure of about 10″ water column into the distributing main. This can be made to serve for shop purposes. To my mind the systems which operate to burn blue gas and other artificial gases most suitably generally require the gas at 10 pounds pressure. In that case a suitable booster running automatically would be installed after the holder. The operating cost would only be in the neighborhood of 2 cents per million B.t.u. for the added pressure and for this cost all air piping, blowers, and all provision for natural draft, such as stacks, for the most part can be eliminated. One also gets the benefit in such systems of automatic mixing and the use of a predetermined proportion of air to gas and a single valve control. However, low pressure gas from the holder and natural draft, or fan blast, can be used satisfactorily if rigid economy is not essential.

Some time ago I ran across an account by F. W. Steere,[1] which shows a comparison between the use of a muffle and its elimination in a given furnace. I am quoting him as follows:

> We might mention that we have built this type of furnace with a muffle (continuous heat treating furnace for automobile parts) to prevent the products of combustion from coming in contact with the steel, the idea of the muffle being to reduce the scaling to a minimum. After several months of comparative tests in running these furnaces with and without the muffle, we concluded that the benefits of the muffle did not warrant the additional expense in construction and operating costs. To maintain an average hearth temperature of 1650° it was found necessary to keep an average temperature in the combustion chamber of 2550° outside the muffle. The average gas consumption is 264 cu. ft. of gas per minute, the average cubic feet of gas per ton of stock being 22,970. The efficiency of the furnace was 14½%.
>
> With the same type of furnace, running exactly the same temperature conditions and delivering the same amount of stock, without the muffle, that is, the products of combustion coming in contact with the steel, we found that the average gas consumption was 150 cubic feet of gas per minute, or 11,500 cu. ft. of gas per ton of stock, with a furnace efficiency of 26% as compared with 14½%, as stated above.
>
> By furnace efficiency we mean the total amount of heat put into the stock divided by the total amount of heat delivered to the furnace in the gas.

Recently I have received some data which will be of interest to those who are annealing glass in leers. The Chattanooga Bottle & Glass Mfg. Co. of Chattanooga, Tennessee, is using coke oven gas on a battery of 5 leers, each leer 5 feet 6 inches wide by 75 feet long, and the fire box is 10 feet long. The inside height of the leers at the front is 14 inches to the level of the chord of the arch. The crown of the arch is 9 inches more. The front of the leers is insulated with insulating brick, also the sides and crown of the fire box. Each leer has a 24-hour production of from 7½ to 8 tons of bottles, milk jars, etc. The temperature in the fire box is maintained at from 1140°F for soda water bottles and milk jars, and about 1060°F on medicine bottles. The consumption of gas is from 625 to 650 cu. ft. per hour per leer. This would be the equivalent of from 326 to 339 cubic feet of 1125 B.t.u. natural gas per hour, or 7580 to 8140 cubic feet of natural gas per 24 hours, or 37,900 to 40,700 cubic feet for the battery of 5 leers per 24 hours. Some of this data ought to enable many glass men to draw a parallel between their own gas consumption for leers and these results which have so kindly been given to me by Mr. William H. Meacham, President of the Chattanooga Bottle & Glass Mfg. Co. in a letter dated January 29, 1923. The total sulphur in the gas being used in this case is reported as being about 8 grains per hundred cubic feet. The heat content of the gas averages about 540 B.t.u. per cubic feet.

G. FITZGERALD:—There are four sources of clean gas: natural gas, manufactured coal gas or coke oven gas, manufactured water gas and washed producer gas. What is the size of the water gas set that would

[1] "American Fuels," pp. 984, 985.

furnish gas at a competitive price with these other gases? There are many instances in which the use of manufactured coal gas is economically sound, but if this is not available one must rely either on manufactured water gas or washed producer gas. Is the gross consumption for which the use of water gas is available, at a competitive price with manufactured coal gas?

A. E. BLAKE:—Blue water gas can be made by the use of chemistry laboratory glassware, etc., if desired. You, however, are doubtless interested in knowing the size of the smallest standard unit which can be operated, as the word standard would imply, on an *economical basis* to make gas to be used for industrial purposes. The case with blue water gas equipment is practically identical with that of nearly any other kind of equipment for making gas or other commodities. To illustrate we can say that the cost of heat units delivered by the smallest commercial sized clean producer gas plant is bound to be at least somewhat higher than for a very large installation of that kind. In the case of blue water gas the size of the smallest standard generator is one having a diameter of 4 feet. Its normal rating is equal to the supply of 2,000,000 B.t.u. as blue water gas per hour. That is about the equivalent of 2000 cubic feet of natural gas per hour. The added cost of blue gas per million B.t.u. from this very small generator will depend a great deal upon circumstances, but would probably be somewhere from 5 cents to 10 cents higher than for a plant of ten times the capacity. The thing holds, I believe, in the case of steam power plants, electric generating stations, fuel oil installations, and the like. The point is illustrated, for instance, by noting that in cities like Boston, Chicago, or Philadelphia, the rate charged for gas is much lower than the rate which obtains in the smaller cities and towns fortunate enough to have even a tiny gas works to cater to their convenience, and all this when the towns and small cities are in the same regions as the larger ones mentioned.

CLAY SEWER PIPE MANUFACTURE

III—The Heat Distribution in Sewer Pipe Kilns[1]

By H. G. Schurecht[2]

ABSTRACT

Purpose.—A study was made of the heat distribution in four sewer pipe kilns in order to determine means of making this as uniform as possible and thus produce pipe of uniform maximum strength and reduce the cost of firing.

Results.—It was found that the coolest portions of the kilns are along the entire bottom and on the top near the outside of the kiln. The hottest portion is usually on the top in center of the kiln. Kilns having a small diameter have a more uniform distribution of heat than those having larger diameters.

Introduction

One of the important requirements for sewer pipe is high strength since they are required to resist considerable external pressure, due to the weight of soils and traffic above them, as well as internal strains, due to the hydrostatic pressure caused by a heavy downpour of rain.

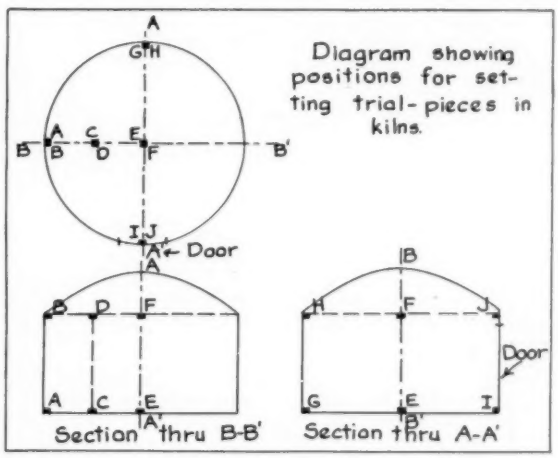


FIG. 1.

In order that pipe of maximum and uniform strength may be produced it is necessary that the kilns should be fired at a specific temperature and that the heat distribution in the kiln should be uniform. There is a certain range of temperature in which each clay develops maximum strength and if this temperature is not reached the pipe will be porous and weak. If it is exceeded the pipe will be too brittle and weak and deform out of shape.

A kiln having a very uniform heat distribution can also be fired faster and hence with less fuel than one in which this distribution varies between wide limits. During watersmoking the ware is fired at a very slow rate

[1] Published through the courtesy of the Eastern Clay Products Association and the Clay Products Association under whose auspices this work has been done as part of their research program on the manufacture of clay sewer pipe.

[2] Industrial Fellow, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

and if the coolest portion of the kiln is 100°C lower than the hottest portion, it would be necessary to continue at this slow rate of firing until

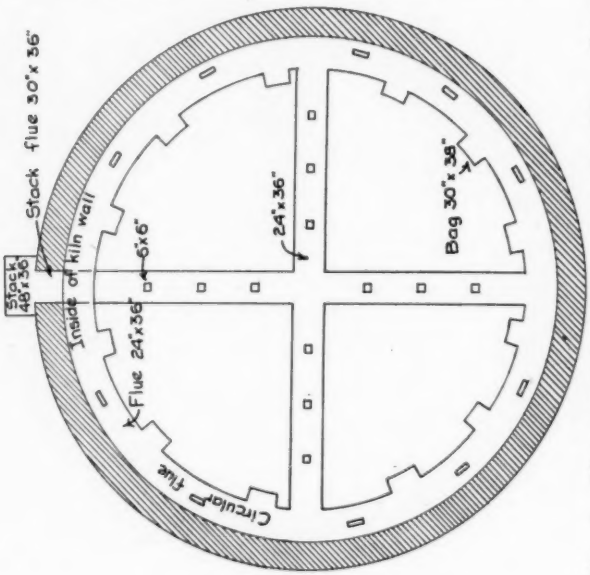


FIG. 3.—Flue system in a 35-ft. sewer pipe kiln. Cross and ring flue system. Type B.

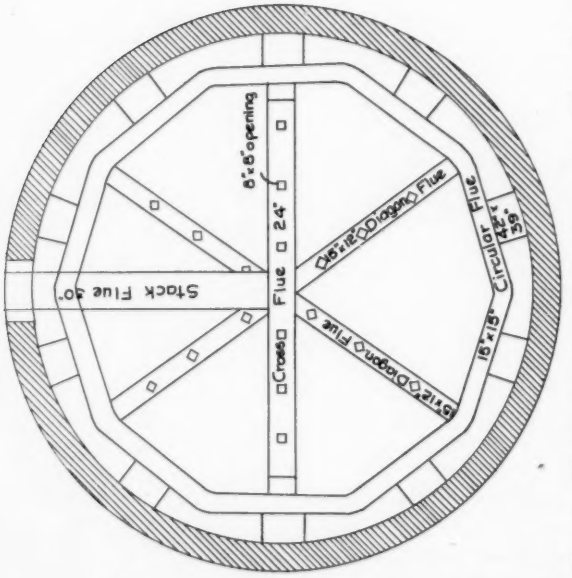


FIG. 2.—Flue system in a 34-ft. sewer pipe kiln. Cross and diagonal flue system. Type A.

the hottest portion is heated 100°C above the watersmoking temperature. A kiln with a more uniform heat distribution could therefore be water-

smoked, dehydrated and oxidized in less time than one with a wide difference in heat distribution.

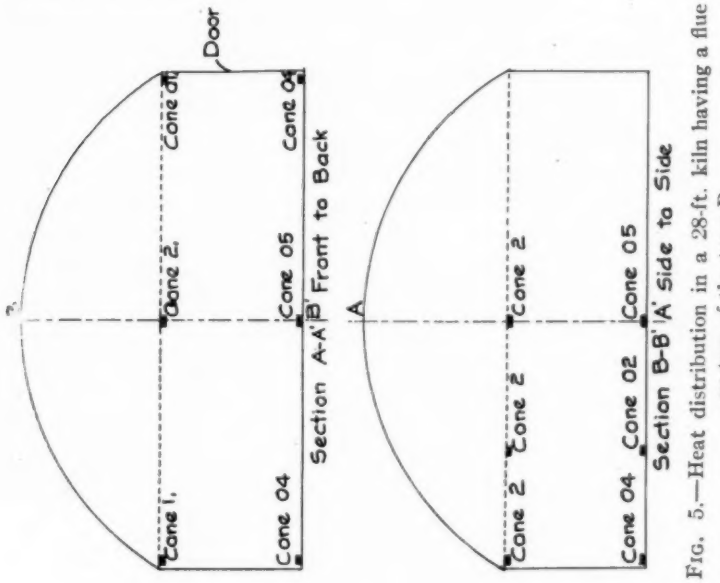


FIG. 5.—Heat distribution in a 28-ft. kiln having a flue system of the type B.

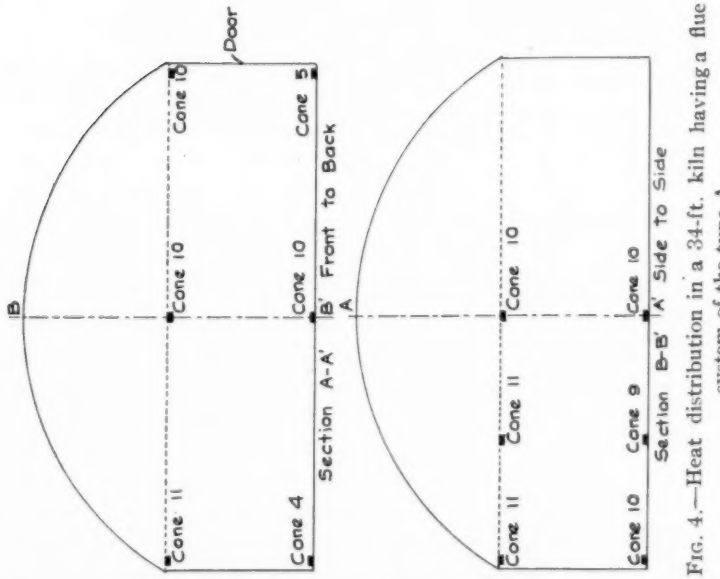
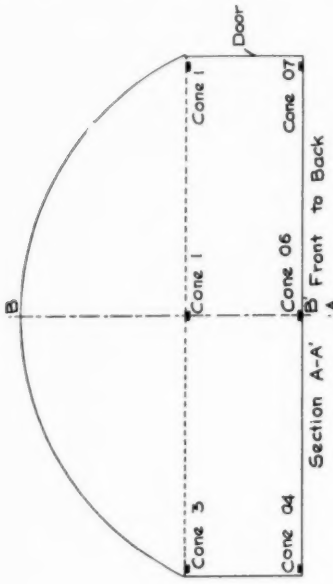


FIG. 4.—Heat distribution in a 34-ft. kiln having a flue system of the type A.

A systematic study is therefore being made of the factors governing the heat distribution in sewer pipe kilns in order to determine means of making this as uniform as possible.

Experimental Methods

4″ x 6″ fire clay saggers, each containing 10 cones, were placed in 10 different positions (Fig. 1) in commercial sewer pipe kilns. The cones



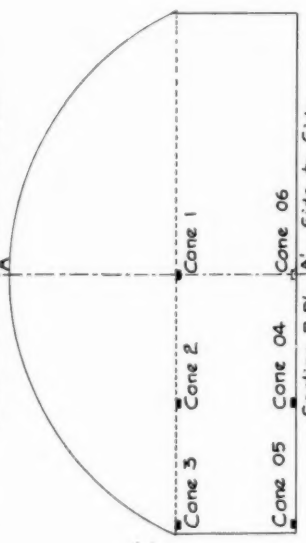
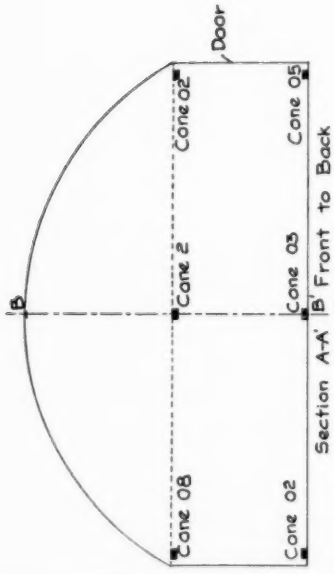


FIG. 7.—Heat distribution in a 35-ft. kiln having a flue design of the type B.



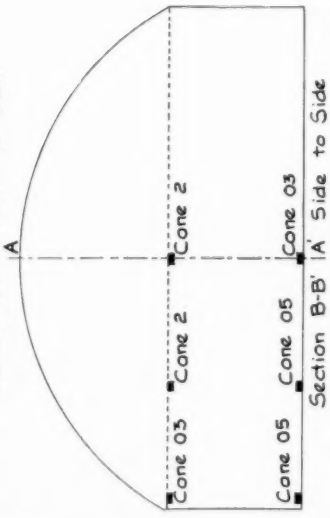


FIG. 6.—Heat distribution in a 30-ft. kiln having a flue system of the type B.

were placed inside of these saggers to protect them from the reducing kiln atmosphere and salt fumes which would cause them to deform prematurely.

This investigation has been conducted in four kilns. One had the type A flue system (Fig. 2). The other three had the type B flue (Fig. 3). The first kiln had an internal diameter of 34 feet and the last three had internal diameters of 28 feet, 30 feet and 35 feet, respectively. The first was fired to cones 10–11 and the last three to cones 2–3.

After the kiln had been fired, the temperatures reached in the different portions were obtained by noting what cones had deformed. The percentages of the kiln volume falling within different ranges of temperature were then calculated and these figures were used to compare the heat distribution in the different kilns.

Experimental Results

The temperatures obtained in the different portions of these kilns are shown in Figs. 4, 5, 6 and 7.

In Figure 4 is shown the heat distribution obtained in the 34-foot kiln having a flue system of the type A. Although this kiln gave the best results of any tested, the temperatures on the bottom in positions G and I were 5 cones lower than the hottest portion of this kiln. These positions are directly in front of the door and "backout" of the kiln and their lower temperatures are apparently due to heat lost through the thinner walls at these places. Using thicker wickets especially in the lower half of the door would reduce the escape of heat at these points and raise the temperatures of these portions of the kiln.

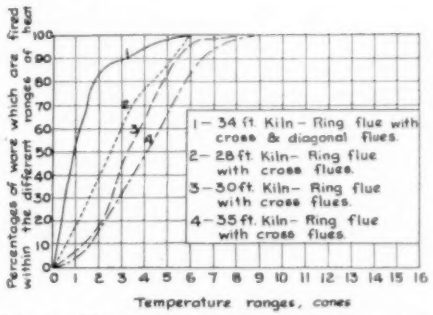

Percentages of ware which are fired within the different ranges of heat
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Temperature ranges, cones
1 – 34 ft. Kiln – Ring flue with cross & diagonal flues.
2 – 28 ft. Kiln – Ring flue with cross flues.
3 – 30 ft. Kiln – Ring flue with cross flues.
4 – 35 ft. Kiln – Ring flue with cross flues.

FIG. 8.—The heat distribution in sewer pipe kilns.

The three kilns fired to cones 2–3 all showed a poorer heat distribution than that fired at cones 10–11. Since kilns fired to high temperatures usually have a more uniform distribution of heat than those fired at lower temperatures, this would partly explain why the kiln fired at cones 10–11 gave better results than those fired at cones 2–3.

In the three kilns fired at cones 2–3, the coolest portions were found to be along the entire bottom and also on top near the outside. The hottest portion is on top in the center. This is partly due to the fact that the area of the brick walls through which heat escapes is much greater for the portion around the outside of the kiln than it is for that portion in the center. It was also found that the kilns with a small diameter had a more uniform distribution of heat than those with larger diameters.

The percentages of the kiln volume, falling within different ranges of

temperature are shown graphically in Figure 8. These percentages were calculated in terms of that volume below the sides of the crown since the crown is seldom filled with ware. The kilns having the upper curves have a more uniform distribution of heat than those having the lower curves.

By examining these curves it is seen that the heat distribution in kiln 1 is far superior to that obtained in kilns 2, 3 and 4. Kiln 2 which has a diameter of 28 feet is heated more evenly than kilns 3 and 4 which are 30-foot and 35-foot kilns, respectively, with the same flue system.

With kiln 1 it is possible to vitrify 90% of the ware if the pipes are made with a body having a vitrification range of 3 cones. The proportions of the ware which would be vitrified in the other kilns are 60 per cent in kiln 2, 44% in kiln 3 and 32% in kiln 4.

Summary and Conclusions

A study was made of the heat distribution in four sewer pipe kilns since in order to manufacture pipe of uniform strength they must be fired in kilns having almost a uniform heat distribution.

It was found that the coolest portions of the kilns are along the entire bottom and on the top near the outside. The hottest portion is usually on the top in the center of the kiln.

There is a large variation in the heat distribution in different kilns. Even those having the most uniform distribution have cool portions in front of the doors due to the rapid escape of heat through the thin walls at these points.

Kilns having a small diameter have a more uniform heat distribution than those having larger diameters.

NOTE: The writer wishes to acknowledge his indebtedness to Dr. E. W. Tillotson for helpful suggestions during the progress of the work and to the sewer pipe manufacturers for their coöperation in conducting these tests.

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THE FIRE BRICK MATERIALS OF PENNSYLVANIA[1]

By George H. Ashley

ABSTRACT

Pennsylvania produces over 40% of all clay fire brick and over 70% of all silica fire brick made in the United States. In 1920 Pennsylvania produced and sold fire clay worth nearly two million, fire clay brick worth nearly twenty-two million, and silica brick worth over ten and one-half million, a total of thirty-four and one-half million dollars worth of brick and clay.

Three kinds of material are used for the manufacture of this fire brick. (1) Soft fire clay from one horizon northwest of Pittsburgh and from the "main clay" of the Pittsburgh bed south of Pittsburgh. (2) Hard or flint clay which occurs in many counties of the State. The hard clays are described as occurring at a limited number of horizons in the Allegheny formation or "Lower Productive Coal Measures," as being irregular in thickness and distribution, ranging from a feather-edge to fifteen or twenty feet in thickness and being of two types, "block" clay in which the structure is homogeneous, and "nodular" clay in which the structure is gnarly or knotty. Brief reference is made to the principal flint clay deposits of the State. (3) The third source of material for fire brick is ganister rock, a pure white quartzite occurring as a massive bedded sandstone at the base of the Silurian series and exposed abundantly in the zig-zag ridges across the central part of the State and as a similar white quartzite at the base of the Cambrian in the southeastern part of the State. A series of tests of flint clays and of soft clays used to mix with the flint clays is appended. These are derived mainly from Clearfield County which is the leading flint clay county.

Introduction

The value of the raw clay and finished clay products produced in the United States annually is exceeded in value among the mineral industries only by coal and petroleum. When it is recalled that the value of clay fire brick manufactured is one-fifth that of the whole industry, and that Pennsylvania produces over 40% of all clay fire brick, and over 70 per cent of the silica fire brick made in the United States, it should be of interest to know how and where fire clays and ganister occur in Pennsylvania.

In 1920 Pennsylvania produced and sold fire clay worth $1,946,772, fire clay brick worth $21,929,602, and silica brick worth $10,629,769, a total of $34,506,143.

Kinds of Materials Used

Three kinds of material are used for the manufacture of fire brick in Pennsylvania, soft fire clay, hard or "flint" fire clay, and ganister. Fire clay is a clay comparatively free from iron and alkalies, not easily fusible, and hence used for making brick to line furnaces. Ganister is a highly refractory siliceous sedimentary rock used for furnace lining or crushed for use in making silica brick.

Soft Clay.—The soft clay used in making fire brick in this State occurs as beds in or under the coal beds. Formerly all clays found under the coal

[1] Presented before the Refractories Division, Pittsburgh Meeting, February, 1923.

beds were called fire clays. As a matter of fact such clays are usually more refractory than clays or shales found elsewhere in the same series of rocks. There is therefore some reason for calling them "fire clays." But experience has shown that as a rule such clays are not sufficiently refractory to meet many or most of the demands made today for a high-grade fire brick. These clays may soften at Seger cones 15 to 25, while the demand may be for brick that will not soften below Seger cone 30. The soft clays are used for fire brick not subject to excessive heat, and especially for brick able to resist abrasion. These clays find large use for mixing with non-plastic but more refractory fire clays, the proportions of the mix being varied with the use to which the brick is to be put.

The soft clays, or "underclays," are commonly drab or blue in color when fresh, but white when weathered; and vary from fair to good in plasticity. They commonly occur as beds directly under the coal or as relatively thin partings between the benches of a coal bed, and are very regular in thickness and character from place to place. The clay beds may vary from top to bottom, the bottom being generally more sandy than the top, but in their horizontal extent beds of clay may cover thousands of square miles, and be more regular and persistent than the coal beds that overlie them.

The soft clays occurring as partings in the coal beds are more regular than the underclays; some beds a fraction of an inch thick can be followed over hundreds or even thousands of square miles. The "main clay" of the Pittsburgh bed is a notable example. This lies directly on top of the mined coal in the Pittsburgh district, separating it from the so-called "roof coal." The thickness is nearly everywhere from 6 to 12 inches, and commonly between 8 and 10 inches.

The soft clays are commonly less than 10 feet thick and probably average less than 4 feet, but locally they may be 20 to 30 feet, or even more. The thickness is more or less characteristic of the beds; certain beds, such as that under the Lower Kittanning or "B" coal, are characteristically thick, other beds are characteristically thin.

Flint Clay.—"Flint clay" is a term used to designate a clay rock that has few of the properties ordinarily ascribed to clay. It is not soft, but so hard that it will ring under the hammer. It is not plastic, but must be mixed with a plastic clay to be molded into brick. It does not soften when wet as do most clays, but will continue to break down into smaller and smaller splintery fragments. Where a flint clay crops out in roads its weathered fragments may crunch under the wheels of a wagon like so much broken glass. Instead of softening at Seger cone 15 to 25 such clays will commonly withstand temperatures up to cones 25 to 35. The flint clays are commonly light drab in color, but range to black or other shades. They break with a conchoidal or hackly fracture much after the manner of

flint (quartz). They differ chemically from the soft clays in their freedom from the so-called fluxes and in their proportions of silica and alumina. The best flint clays contain less than 3% of iron oxide, lime, magnesia and alkalies taken together, in contrast with the soft clays which usually contain over 5% of those substances. This statement refers particularly to the high-grade flint clays. Flint clays with a larger percentage of iron, in particular, are not uncommon, and in many places the unweathered clay contains a large percentage of iron oxide which gathers into "iron balls" where the clay is weathered. The weathered clay has value because the iron balls can readily be removed. Chemically the flint clays have almost the composition of kaolinite. Locally they may carry more than the normal percentage of alumina and become potential ores of aluminum. This is due to the presence of diaspore or gibbsite—aluminum hydrates.

There are two types of flint clay, block and nodular. In "block" clay, the structure is homogeneous and the grain appears as smooth and fine as in a siliceous flint; in the other the clay occurs in nodules. "Nodular" clay has sometimes been assumed to be of low grade. On the contrary the high alumina clays appear to be commonly of the nodular type.

Flint clay occurs in beds usually in association with soft clay. The association is commonly such as to suggest that the flint clay is the result of changes taking place in the soft clay. It has been suggested that a flint clay consists of tabular crystals of kaolin, and because of this crystalline condition the beds are not plastic and do not soften when exposed to the weather. The crystals are extremely fine—so fine that in some instances doubt has been expressed as to whether the rocks were crystalline or colloidal. Evidences of the possible secondary character of the flint clay are: first, the extremely irregular shape of many of the deposits; second, in the same bed the flint clay at one point may be above the soft clay, at another below, and at still another between two benches of the soft clay; third, in certain deposits flint clay appears to be confined to the zone of weathering. A bed that yields excellent flint clay at the surface may, a short distance in the hill, yield only soft clay. Notwithstanding the irregular character of individual beds, the deposits appear to be confined to certain few horizons as though the original clays in those horizons differed in some essential from other clays. Furthermore, in a few instances flint clays lie in fairly regular beds having considerable extent. In northern Beaver County, Pennsylvania, a flinty clay occurs so persistently a short distance above the Upper Freeport coal and over so large a territory as to have proved a valuable key rock in working out the geology of that region.

Most of the deposits with which the writer is familiar are extremely lenticular. For example, a drill hole in Clearfield County penetrated 5

feet of high-grade clay, but an entry driven so as to cut the drill hole showed that the clay pinched out in less than the width of the entry. Experience has shown that the flint clay below the Lower Kittanning or "B" coal is especially likely to have a distinct relation to the surface. Many mines opened in this bed started with 5 to 15 feet of clay which pinched out in a few hundred feet on driving into the hill. On the other hand, here and there, mining has revealed bodies of clay that appeared to maintain their thickness and quality regardless of distance from outcrop or depth of cover, as at Woodland, Clearfield County, Pennsylvania.

Deposits of flint clay may be 20 feet thick or more, but usually are less than 5 feet. The thickness of both flint and soft clay combined does not seem to bear any relation to the thickness of the overlying coal. In many mines on the thick and regular bed of Mercer fire clay the overlying Mercer coal is only a few inches thick or has disappeared altogether. In the same mine the coal may vary from a few inches to 2 or 3 feet apparently without affecting the thickness or quality of the clay.

Ganister.—Ganister is a name given to certain flux-free sandstones. This material is used in the form of stone dressed to the desired shapes, as brick, and as sand to line furnaces and ladles. The largest use of ganister is in the manufacture of silica brick for lining glass furnaces and furnaces making steel by the acid process.

Experience has shown that the best material for brickmaking is quartzite, a sandstone in which the quartz grains are cemented by secondary silica, so that the rock is more firmly cemented and less porous than before. Such a rock when crushed breaks down, not to round grains of sand but to splintery fragments, because the rock fractures across grains and cement alike. The splintery character of the ground material gives binding power and strength to the brick.

Although certain of the sandstones found in the coal measures have been used as ganister, the most satisfactory ganister found in Pennsylvania is in two beds of quartzite, each several hundred feet thick and of great extent. Further, it has been found that the best rock is that which has broken away from the main ledges and now mantles the subjacent hill slopes. The weathering to which these blocks have been subjected appears to have removed some of the iron oxide found in the unweathered rock.

Geological Occurrence of These Materials

If, beginning with the rocks in which are found the oldest known fossils, all geologic time be divided into ten ages, the first five may be designated from the bottom up as Cambrian, Ordovician, Silurian, Devonian and Carboniferous. The last includes the coal measures. The rocks of these ages underlie nearly the whole of the Commonwealth of Pennsylvania and are tens of thousands of feet thick. Within this great series of rocks

the refractory materials to which reference has been made are confined to a few hundred feet at three separate horizons. Ganister is obtained in Pennsylvania almost exclusively from two bodies of massive sandstone or quartzite, one at the base of the Cambrian, the Chickies quartzite, and the other at the base of the Silurian, called the Medina (Tuscarora) sandstone. The Chickies quartzite, named from Chickies Rock on the Susquehanna River above Columbia, crops out in the southeast part of the State. The Medina sandstone has a very wide extent, underlying all of western New York, two-thirds of Pennsylvania, and all of eastern Ohio.

The fire clays used in Pennsylvania come almost entirely from a thin series of rocks near the middle of the Carboniferous known as the Allegheny formation. This formation corresponds to what was formerly called "Lower Productive Coal Measures." It consists of shales and sandstones with from 5 to 12 coal beds, each underlain by a bed of clay. These beds of clay furnish the soft clay of the State, and it is in association with them that the flint clays are found. The Allegheny formation is commonly divided into three members: the Freeport at the top contains an upper and lower coal, each underlain by clay; the Kittanning member contains usually three coals, an upper, middle, and lower; and the Clarion contains two coals, the Clarion and Brookville. Of the soft clays associated with these coals, that under the Lower Kittanning has proved of most value. It is usually the thickest clay of the group, and in general is more regular and of better quality than the others. Locally the other clays are of good thickness and quality.

The flint clays are mainly derived from three horizons. The highest known as the Bolivar clay, occurs below the Upper Freeport coal. The second, the Clarion, occurs a short distance below the Lower Kittanning coal, though sometimes separated from the Lower Kittanning underclay by many feet of shale. The third horizon is at the base of the Clarion member, or a little below. Recent work has disclosed some confusion in the identification of the rocks at or below the base of the Allegheny formation, so that it is not quite certain whether we are dealing with one bed or two; in other words, whether the lowermost flint clay is at the base of the Clarion member or in the Mercer member down in the underlying Pottsville, or whether there are two clays, one at each of these horizons.

Distribution

Soft Clays

The use of soft clays for making fire brick without mixture with flint clays is confined mainly, if not entirely, to the western end of the State. There are two centers of such use, one around the mouth of Beaver River, the other on Monongahela River near Monongahela City.

In the Beaver district clay is obtained locally from below the Lower Kittanning or "B" coal. The part of the bed used is 6 to 8 feet thick, the lower part being too sandy. Brick from this clay is suitable for use in the upper part of furnaces where high resistance to abrasion is necessary. They will not stand the high heat of the bottom of the furnace. There are a half dozen or more plants in the Beaver district, some of which also use flint clays from the center of the State. Plants are located around Beaver, Rochester, and New Brighton, Conway Station, Monaca, Vanport, and elsewhere.

The fire brick plants on Monongahela River use the clays from the waste heaps or gob of mines on the Pittsburgh coal. This clay, which makes the parting between the main coal and the overlying "roof coal," is from 6 to 10 inches thick. The clay is used principally for making sleeves, nozzles, and runners for steel works. It has been mined at Manown, Watson Station, and Courtney.

Soft clays used as a bond with flint clays are in general mined close by the fire brick plants wherever those plants are situated.

Flint Clays

Good flint clays are rather widely distributed over the coal measure area of the State. The leading districts are in Clearfield, Center, Clinton, Fayette, Westmoreland, Clarion, Armstrong, Cambria, and Indiana counties, with scattered plants in other counties. Probably the most valuable of the clays is that at the base of the Allegheny formation or Mercer horizon. The Bolivar clay occurring beneath the Upper Freeport coal comes next, and the Clarion clay under the "B" coal is third. Locally flint clays occur under other beds and above the Upper Freeport coal. A brief reference to the principal producing areas by counties follows:

Armstrong County.—The Mercer clay has long been mined in northern Armstrong County at St. Charles, where it is 6 to 10 feet thick, including $2^1/_2$ feet of flint clay. At the toe of Anthony's Bend, above Climax, the clay is only 75 feet above the creek and 12 feet thick, including both soft and hard clay. The Clarion clay is a semi-plastic clay one mile northeast of Kittanning. Both the Clarion, Lower Kittanning, and Upper Freeport clays are mined in this county, but only locally carry flint clay. Flint clay was formerly mined at Manorville from the Bolivar horizon. The soft clays of this county are much used for bonding flint clays, and are used alone to a small extent for fire brick.

Cambria County.—Cambria County has produced some flint clays from the Mercer horizon in South Fork district. The clay is up to $4^1/_2$ feet thick, and overlain by a few inches of coal. Flint clays occur at the horizon of the Bolivar bed and within 100 feet above it, and have been tested around Johnstown and farther north in the county. Several firms

at Johnstown are making fire brick, using both local clays and clay from South Fork.

Cameron, Elk, and Clinton Counties.—There are fire brick plants in Cameron, Elk, and Clinton counties, but the source of the raw material is uncertain, as these counties have not been studied in recent years in detail. Hard clay 4 to 9 feet thick, variously described as belonging to the Sharon horizon at the base of the coal measures, or at the Mercer horizon somewhat higher up, has been worked at Cameron, Cameron County, in the neighborhood of Benezette, between Benezette and Rock Hill, and on Laurel Run, in Spring Creek township, Elk County. The Mercer clay, or a clay at the base of the Allegheny formation, is being worked at Farrandsville and Queens Run, Clinton County, and a hard clay supposed to be under the Middle Kittanning or "C" coal is being mined on Tangascootack Creek in Clinton County.

Clarion County.—The Mercer fire clay has been mined at Climax and St. Charles on Redbank Creek, on the boundary between Clarion and Armstrong counties. The most widespread clay in Clarion County is the "Clarion" clay under the Lower Kittanning or "B" coal. This clay is fairly persistent over a belt 3 to 5 miles wide along Clarion River in the vicinity of Clarion town. It has been mined at Sligo and at several places near Clarion Junction and Piney, and its outcrops in the roads reveal its presence over a broad area. As seen in some of the strippings the flint clay appears to be very irregular, occurring in places as great irregular masses in the soft clay. The thickness ranges from 2 to 5 feet.

This clay is now being extensively mined $2^1/_2$ miles southeast of Clarion on the Lake Erie, Franklin and Clarion Railroad near the Harvey mine on the Dean Klahr farm, by the Clarion Refractories Company. The flint clay will average 4 feet, with a maximum thickness of 9 feet. It is overlain by semi-flint 5 feet thick, and 20 feet above that is about 6 feet of soft clay under the Lower Kittanning coal. Clay has been mined at Lucinda 8 miles north of Clarion for 30 years or more. This clay is shipped to Ohio for furnace use. It is reported to be from 8 feet to a feather edge in thickness.

Clearfield County.—Probably the leading flint clay county of the State is Clearfield. Separate figures for fire clay are not available, but in 1920 the terra cotta and fire clay production in this county was valued at $8,087,900. This does not include the value of clay shipped for use out of the county. The principal deposits are in Ferguson, Pike, Bradford, Boggs, Decatur, and Karthaus townships. In Ferguson township the Mercer clay is being mined at Lumber City a short distance above river-level. The flint clay is 6 feet thick or more. In Pike township flint clay is mined at a number of places around Stronach where the "nodular" clay is from a knife edge to 6 feet thick, and the "block" clay below from

2½ to 7 feet thick. Up Anderson Creek above Clearfield in a number of mines the flint clay is from 2½ to 10 feet thick. On Hogback Run the bed is reported to show locally as much as 8 feet of nodular clay overlying 11 feet of block clay. In places this changes to as high as 11 feet of nodular clay over 7 feet or more of block clay.

Flint clay is found at several horizons around Clearfield but apparently is not so high grade as farther east. The works at Clearfield are therefore mainly on the soft clay, or are using flint clay shipped in. Fire clay is mined at many places along Clearfield Creek, including Clearfield Junction, where two beds have been mined, Krebs Station where the Clarion clay is being mined, Faunce, Chase, and other points. At most of these places the clay mined is at the Mercer horizon. The flint clay portion of the bed is from 2 to 6 feet thick, overlain by thin Mercer coal.

In Bradford township flint clay has been or is being mined at Barrett Station, Mineral Spring, Woodland, Bigler, and over wide areas south of the last two places, and outcrops at many other points in the township. Both the Mercer and Clarion beds are mined. The Mercer bed is the more persistent and valuable, having a maximum thickness of 10 or 12 feet, though the portion mined and the average thickness will commonly range from 2½ to 4 feet.

Flint clay has been found at many places in Boggs township, especially west and southwest of Blue Ball, and at many points in the Morgan Run drainage.

The northwest corner of Decatur township around Burley is a nest of mines. The Mercer clay here, as west of Blue Ball, is near the top of the hill and has been extensively stripped though most of the workings are underground. In general the flint clay of this district is from 6 to 8 feet thick, though locally reaching 12 to 15 feet.

Flint clay crops out or is found by drilling over a considerable area in eastern Woodward township. Around Westover in Chest township is a small area of flint clay under the Upper Kittanning or C′ coal.

Centre County.—Flint clay at the Mercer horizon has been worked from an early day at Sandy Ridge and Powelton in Centre County. The flint clay is from 2 to 4 feet thick, associated as usual with soft clay. Fire brick has also been made at Clarence and Orviston in the same county, but the writer has never examined the clay at these points.

Fayette and Westmoreland Counties.—The flint clay in these counties is localized in three districts. The first is where the Fayette anticline brings up rocks of Allegheny age on Youghiogheny River and Sewickley Creek. The second district is along the western foot of Chestnut Ridge where the same rocks are brought up to the surface by the upturning along the ridge. The third district is along Kiskiminitas River where the clay in the Allegheny formation is exposed again.

In the first district mining centers around Layton Station, the mines being in the Bolivar clay and in the clay below the Lower Kittanning coal. Some clay has also been mined about 130 feet above the Upper Freeport coal. At Layton there is from 8 to 12 feet of hard clay over soft clay, the whole bed having a thickness of 6 to 20 feet.

Mining on the western flank of Chestnut Ridge has extended for a long distance in Fayette County and in Westmoreland County to Conemaugh River. Among places of special note are Bailey's Point below Bear Creek Station, Henninger Mills near Dunbar, Pechin Station, Mt. Braddock, Lemont Furnace, and White House near the south State line.

The flint clay is mined from the Bolivar and Mercer horizons. At most of these places the flint clay has a maximum thickness of 12 or 15 feet. Mining as a rule has been confined to the outcrop because experience has shown that beyond the zone of weathering the clay contains too much iron, but within that zone the iron has been brought together in the form of "iron balls," which are easily separated. The type locality of the Bolivar clay is at Bolivar where Chestnut Ridge is cut by Conemaugh River. The flint clay has been mined here extensively and has a maximum thickness of over 20 feet. Clay has been mined still farther north in Indiana County along the west flank of Chestnut Ridge at the Mercer horizon and averages 11 feet thick. The clays from this belt along the western side of Chestnut Ridge have been used largely in making brick for building beehive coke ovens. The Bolivar clay has also been mined at Salina farther down Kiskiminitas River, the flint and soft clay together being from 6 to 13 feet thick. The clay is irregular in thickness, varying from 12 feet to 2 feet within the same mine.

Indiana County.—Clay 3 to 11 feet thick has been mined at Black Lick from the Mercer horizon; and on the west slope of Chestnut Ridge $1^1/_2$ miles east of Black Lick.

There is little doubt but that detailed studies will reveal flint clays or soft clays suitable for refractory brick at many other places in the State.

Ganister

Occurrence.—As already pointed out ganister is obtained from two formations, the Medina (Tuscarora) sandstone or quartzite, and the Chickies quartzite. The Medina (Tuscarora) sandstone at the base of the Silurian lies several thousand feet underground in the coal fields of the State. Between the Allegheny Front and the Cumberland-Lebanon-Lehigh Valley it is brought to outcrop by folding of the strata and is the principal ridge maker. In most of the ridges of that district the sandstone is more or less turned up or vertical. These ridges zigzag across the central part of the State, forming a line of outcrop hundreds of miles long.

The physical character of the sandstone varies from place to place.

The supply of material for silica brick has come mostly from the sandstone talus on the ridge slopes. The talus is not present everywhere on the slopes, and not all of it is valuable for making brick.

The second source of ganister, the Chickies quartzite, occurs only in the southeast corner of the State, that is, southeast of the Cumberland-Lebanon Valley. This quartzite has a fairly extensive outcrop in that region but to date has been used only in a minor way for the manufacture of brick.

The counties best known for the occurrence of ganister are Blair, Huntingdon, Centre, Mifflin, and Juniata. Ganister has been quarried recently at Bedford and Madley, Bedford County, Hollidaysburg, Blair County, and Mount Union, Huntingdon County. The ganister rocks of Pennsylvania have recently been studied in detail by Professor Moore, both in the field and laboratory. It is hoped an abstract of his report may be issued before long.

Reserves

Although the quantity of ganister occurring as talus or broken blocks on the mountain sides may be seriously depleted in a few decades the quantity of unweathered quartzite is practically limitless. It remains to be seen whether the unweathered quartzite will prove as suitable for silica brick as the weathered material now forming a mantle of talus over the ridge slopes.

It is difficult to estimate closely the reserves of flint clay. The deposits are so small, scattered, and irregular that only the crudest estimate is possible. It may safely be said that, including areas not yet tested but reasonably certain of being productive, there is enough flint clay in sight to supply the demand at the present rate for 25 to 50 years. Large areas in northern Clearfield and adjoining counties may prove to contain large reserves of flint clay, perhaps sufficient to meet the demand for the next 100 years. The State Survey plans to make a detailed investigation of all the flint clay areas of the State.

Character of Clearfield County Flint Clay

When the writer was making a detailed geologic map of southern Clearfied County several years ago, samples of flint clay in the area were collected by Mr. J. H. Hance. These samples were tested by the United States Bureau of Standards. The results are given in the following tables.

SOURCE AND CHARACTER OF CLEARFIELD COUNTY FIRE CLAY SAMPLES

1. Jno. Brotherlin mine, Faunce. A refractory flint fire clay which retains a porous structure at 1475°C.
2. Good mine, Morgan Run. A refractory flint fire clay which retains a porous

structure at temperatures up to 1475°C. Mixed with a plastic refractory clay it may be used in the manufacture of fire brick.

3. Faunce mine, Faunce. A refractory flint fire clay which retains a porous structure at temperatures up to 1475°C. Mixed with a plastic refractory clay it may be used in the manufacture of fire brick.

4. Cornwath mine No. 2, underlying coal, Cornwath. A fairly plastic buff burning fire clay which vitrifies at 1150°C and becomes vesicular at 1180°C. It may be used in the manufacture of porous building brick. Has no value in manufacture of refractories.

5. Soft clay, Krebs. A plastic buff burning fire clay which vitrifies at 1200°C. It may be used in the manufacture of buff colored building brick. It may be used in the manufacture of low grade refractories.

6. Shale bank, Krebs. A plastic buff burning clay of low refractoriness which vitrifies at 1175°C. It would be of value in the manufacture of building brick. It has no value in manufacture of refractories.

7. Ross mine, Lumber City. A refractory flint fire clay which retains a porous structure at temperatures up to 1475°C. Mixed with a plastic clay it may be used in the manufacture of fire brick.

8. Ross-Bloom mine, above Curwensville. A refractory flint clay which retains a porous structure at 1475°C, although its softening point (cone 32) is low for materials of this type. Has value in manufacture of refractories.

9. Hard clay mine, Stronach. A refractory flint clay which retains a porous structure at 1475°C. May be used in the manufacture of refractories.

10. Nodular clay, Stronach. A refractory flint fire clay which when mixed with a plastic refractory clay may be used in the production of fire brick.

11. Soft clay mine, Stronach. A buff burning plastic fire clay which vitrifies at 1150°. It may be used in production of building brick, etc., but has no value in the manufacture of refractories.

12. Shimmel mine, Wallaceton. A very refractory flint fire clay which retains a porous structure at high temperatures. When mixed with a plastic clay it may be used in the manufacture of refractories.

13. Upper hard clay, Woodland mine, Woodland. Refractory flint fire clay which retains porous structures at high temps. May be used in manufacture of refractories.

14. Soft clay, Shimmel mine, Wallaceton. Buff burning fire clay of somewhat low plasticity and vitrifying at 1180°C. May be used in production of low grade refractories or of building brick.

15. C′ clay, middle hard, Plane mine, Woodland. Flint fire clay which remains porous at 1475°C, although its softening point (cone 31) is somewhat low for the production of high grade refractories.

16. Lower soft clay, Woodland mine, Woodland. Refractory plastic fire clay which burns to dense structure at 1450°C, and has a high softening point (cone 32) for a plastic clay. Has value as plastic bonding clay for manufacture of refractories.

17. Upper low grade hard clay, Woodland. Refractory flint clay which remains porous at 1475°C, although the softening point (cone 30) is too low for manufacture of No. 1 refractories.

18. Lower clay 16½ inches thick and 1 foot below A coal. Soisson mine, S. Sandy River, Bolivar, Westmoreland County. A refractory plastic fire clay vitrifying at 1350°C. This material may be used as bond clay in the manufacture of refractories.

TABLE I

CHARACTER OF CLEARFIELD COUNTY FIRE CLAYS

Sample number	Molding behavior	Water of plasticity in per cent dry weight	Volume drying shrinkage in per cent dry weight	Softening point in Seger cones
1	Non-plastic	12.4	5.1	33+
2	Non-plastic	12.1	4.8	33
3	Non-plastic	12.3	4.8	33
4	Fair plasticity	18.8	13.7	25
5	Very fair plasticity	18.6	13.6	26
6	Good plasticity	..	..	8
7	Non-plastic	13.2	5.4	33
8	Non-plastic	13.7	5.5	32
9	Non-plastic	12.7	4.9	32+
10	Non-plastic	13.2	3.5	33
11	Very fair plasticity	20.3	14.1	15+
12	Non-plastic	13.3	5.9	33+
13	Non-plastic	12.2	4.6	33
14	Slightly plastic	18.1	13.0	29
15	Non-plastic	16.1	7.8	31
16	Fair plasticity	16.8	10.6	32+
17	Non-plastic	12.3	4.3	30
18	Very fair plasticity	18.2	12.6	29

TABLE II

POROSITY AND BURNING SHRINKAGE OF CLEARFIELD COUNTY FIRE CLAYS AT DIFFERENT TEMPERATURES (CENTIGRADE)

a = Per cent porosity

b = Per cent volume burning shrinkage in terms of dry volume

Sample No.		1000°	1030°	1060°	1090°	1120°	1150°	1180°	1210°	1240°
1	a	..	25.5	25.4	25.7	25.1	24.2	23.3	23.2	23.3
	b	..	12.1	12.2	12.9	13.7	15.5	16.3	16.8	17.2
2	a	..	30.0	29.7	29.3	29.4	28.9	28.6	27.4	27.4
	b	..	4.0	5.7	7.0	7.6	7.5	8.9	9.4	10.2
3	a	..	25.8	25.7	25.2	24.6	24.7	23.8	24.5	24.2
	b	..	9.8	10.8	11.3	12.1	12.6	12.5	12.8	12.0
4	a	22.7	21.8	18.4	15.4	13.0	9.6	12.7	17.7	21.8
	b	5.6	7.8	10.4	13.5	15.3	16.5	8.1	2.2	..
5	a	..	26.1	24.5	22.3	19.6	16.4	13.2	11.0	9.6
	b	..	4.2	6.1	8.2	10.5	13.8	15.1	12.3	7.6
6	a	..	28.0	24.9	19.2	13.9	12.4	9.6	8.9	7.6
	b	..	1.0	5.1	10.3	14.7	16.9	18.6	18.8	18.0
7	a	25.4	25.8	24.9	24.4	24.3	23.4	23.1	22.6	22.2
	b	9.1	10.3	10.6	12.4	13.1	13.2	13.8	13.8	12.2
8	a	..	27.1	26.5	26.4	26.5	26.4	26.0	26.0	25.5
	b	..	9.0	10.4	11.8	12.5	12.9	12.3	12.4	12.6
9	a	..	25.7	25.8	25.0	24.6	23.5	24.1	22.9	23.7
	b	..	12.5	13.3	14.0	15.2	15.9	16.1	16.5	16.3
10	a	..	33.9	33.8	32.8	34.2	34.1	33.8	32.9	33.1
	b	..	2.8	3.3	3.8	3.9	5.4	7.2	7.6	8.2
11	a	24.9	23.5	20.8	15.7	9.0	6.0	6.9	21.2	..

	b	5.4	8.5	12.0	16.1	18.6	20.4	8.0	..	..
12	a	28.0	27.6	25.1	27.1	27.5	27.9	27.2	26.7	25.9
	b	8.6	8.4	9.1	9.5	9.8	10.9	11.4	11.9	11.9
13	a	..	25.8	25.8	24.9	24.2	23.7	23.2	23.7	23.0
	b	..	11.5	13.0	13.4	14.9	15.4	15.7	15.8	16.6
14	a	..	25.2	23.7	20.7	17.8	13.7	10.6	10.9	11.3
	b	..	5.4	8.5	11.3	14.2	16.5	16.1	8.8	4.2
15	a	..	29.4	29.4	29.6	30.4	29.8	29.9	30.4	29.5
	b	..	0.6	0.9	1.4	2.0	2.5	3.0	2.7	2.4
16	a	..	27.4	25.7	24.1	22.5	21.1	20.1	19.9	19.0
	b	..	5.8	8.7	10.9	12.6	13.6	..	16.0	17.6
17	a	..	26.6	25.5	25.4	25.1	24.5	23.6	23.8	23.9
	b	..	9.1	11.8	13.4	15.9	16.6	16.4	16.8	16.5
18	a	32.3	26.7	24.7	23.3	21.0	18.2	16.7	14.2	12.7
	b	1.0	1.6	3.2	5.3	8.2	9.8	12.0	13.3	14.5

Sample	No.	1270°	1300°	1325°	1350°	1375°	1400°	1425°	1450°	1475°
1	a	22.9	22.0	22.1	22.7	22.1	22.3	21.4	..	20.9
	b	17.3	17.2	..	..	..	..	..	..	..
2	a	26.9	25.7	25.9	26.3	26.4	26.1	25.8	..	25.1
	b	10.7	11.3	..	..	..	..	..	..	..
3	a	24.1	24.4	22.3	22.4	23.4	24.7	21.6	21.9	21.8
	b	11.1	9.9	..	..	..	..	..	..	..
4	a	..	..	..	..	..	..	..	..	..
	b	..	..	..	..	..	..	..	..	..
5	a	8.6	8.2	9.6	10.8	8.1	8.3	..	7.2	8.7
	b	6.2	..	..	..	..	..	..	..	..
6	a	16.8	..	..	..	..	..	..	..	..
	b	..	..	..	..	..	..	..	..	..
7	a	22.0	..	21.3	21.9	20.8	21.1	20.4	19.1	19.0
	b	11.6	..	..	..	..	..	..	..	..
8	a	24.4	24.6	22.1	23.8	23.3	23.4	23.4	..	22.5
	b	12.6	11.3	..	..	..	..	..	..	..
9	a	23.5	23.8	22.7	23.1	22.6	22.4	22.2	22.2	20.8
	b	15.9	15.0	..	..	..	..	..	..	..
10	a	33.1	32.4	32.7	32.0	32.0	33.7	32.6	..	33.4
	b	8.4	8.6	..	..	..	..	..	..	..
11	a	..	..	..	..	..	..	..	..	..
	b	..	..	..	..	..	..	..	..	..
12	a	..	26.5	27.3	27.8	27.2	26.9	26.3	26.1	24.0
	b	..	10.7	..	..	..	..	..	..	..
13	a	23.0	22.5	22.3	22.1	21.7	21.4	..	21.3	20.3
	b	16.6	16.6	..	..	..	..	..	..	..
14	a	12.1	..	..	..	..	..	..	..	..
	b	..	..	..	..	..	..	..	..	..
15	a	29.7	29.7	29.0	29.0	29.3	..	28.8	..	27.8
	b	0.9	0.3	..	..	..	..	..	..	..
16	a	18.4	18.3	14.6	14.8	14.6	13.3	12.0	..	9.7
	b	18.1	18.1	..	..	..	..	..	..	..
17	a	23.3	22.8	19.4	19.7	20.0	20.1	21.5	..	19.9
	b	15.8	14.2	..	..	..	..	..	..	..
18	a	11.1	..	5.3	2.9	2.3	3.1	5.3	3.8	1.6
	b	14.3	..	..	..	..	..	..	..	..

EFFECT OF TIME AND TEMPERATURE UPON THE CHLORINATION OF FLINT FIRE CLAY

By Herbert F. Kriege

ABSTRACT

An experiment is described in which flint fire clays were chlorinated at fixed temperatures between 500 °C and 950 °C and for varying periods of time. A replaceable condensing system permitted the rate of formation of the volatile chlorides to be studied.

It is a well-known practice to prepare the chlorides of many elements from their respective oxides by passing chlorine over these oxides heated to suitable temperatures in the presence of some reducing agent, as carbon. Recent literature reveals some efforts along theoretical lines[1] and quite a number of patents[2] pertaining to the chlorination of clays and some other silicates under the above conditions. The experiments in this paper deal with the partial chlorination of flint fire clays.

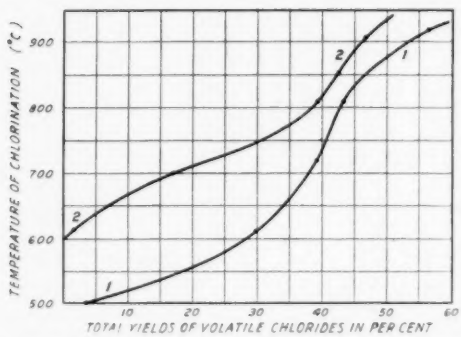

Fig. 1.—Abscissae, total yields of volatile chlorides in per cent; ordinates, temperatures of chlorination.

The two clays used in this experiment were taken from some pits near Warrenton, Mo. Both agreed fairly well with the composition of kaolinite, the total percentage of the oxides other than silica, alumina, and water being less than one-half per cent. Clay No. 1 contained some organic matter and was quite free from grittiness; clay No. 2 contained some free silica and was quite hard.

To prepare a charge for a run, the clay was ground to pass 100-mesh, boiled for one-half hour with a half normal solution of sulphuric acid to free it from the soluble impurities, then dried at 105 °C for two hours. A weighed sample was then moistened and thoroughly mixed with the amount of lampblack theoretically necessary to reduce all the metallic oxides present in the clay. The lumpy mass was dried at 105 °C, reground to pass 50-mesh and placed in the central portion of a silica combustion tube. Loosely fitting plugs of filter paper kept the charge in place until the run was started.

Heating of the charge was conducted in an electric resistance combustion furnace. With the aid of a pyrometer calibrations were made on the furnace before and during a run. Between the temperatures 450 °C

[1] M. J. Barlot and Ed. Chauvenet, *Comptes Rendus*, **157**, 1153, etc.

[2] U. S. Pat., Weaver, 1,238,604; 1,217,471, etc.; German Patents, Siemens-Halske, 289,909; R. van Lieden, 267,876, etc.

and 970°C it was possible to control it to within 30°C. The chlorination products were collected in a condensing train attached to the combustion tube.

The chlorine was prepared by the action of concentrated hydrochloric acid upon a mixture of potassium permanganate and manganese dioxide. Such a flow of chlorine was maintained that the rate of evolution of the gas after passage over the charge and through the condensing system was approximately 0.15 liters per minute. The chlorine was dried by a fourteen inch calcium chloride tower. Some hydrogen chloride was probably in the gas stream, from the acid used in the chlorine generator, and from the combination of the chlorine with the water held chemically in the clay at temperatures below 450°C.

The diameter of the condensing system was nowhere less than two centimeters to prevent choking by the chlorides formed. By keeping various parts of the train at the following temperatures above 200°C, from 85° to 95°C, and below 18°C, it was hoped to effect a fairly complete separation of the volatile products into ferric chloride, aluminium chloride, and silicon tetrachloride, respectively. The 500-cc. flasks which served as receptacles for the various chlorides could be replaced by others during a run. The plan of separation was not very successful, so the products caught were combined and the analysis was made upon the whole. Using clay No. 1, quite a large amount of chlorides formed in the residual charge and collected in the tube during cooling, the flow of chlorine being maintained. These products were recovered by washing out the tube well with water, the wash being boiled for thirty minutes, filtered, and analyzed in the usual way. This is referred to in the tables under the heading "Water Soluble Residue." With clay No. 2 chlorine was not passed over the charge during cooling. The percentages given in the tables following are as oxides on the basis of the original sample of washed clay.

In order to insure uniform conditions, the temperature of the furnace was brought to the desired degree before the run of chlorine was begun. The moisture from the dehydration of the clay during the preliminary heating was removed as completely as possible by a gentle stream of air.

With the hope of obtaining some information on the rate of chlorination, the condensing system was replaced at three intervals during the run. In run E with clay No. 1, for example, the condensing system was replaced after chlorine had been passing through for 25 minutes which is called "period a;" the chlorination was then continued for 30 minutes (period b), when a third system was inserted and the run continued for 35 minutes more (period c). The amounts of products retained during each period were then determined, and the rate, expressed in per cent per minute, was calculated. The data obtained at the different temperatures are given in condensed form in the tables which follow.

TABLE I—CLAY NO. 1

Run / Temperature		A 500°C	B 605°C	C 715°C	D 810°C	E 915°C
Time	a	17 min.	17 min.	20 min.	20 min.	25 min.
	b	33 min.	33 min.	50 min.	30 min.	30 min.
	c	40 min.	40 min.	35 min.	40 min.	35 min.
Sample weight		4.0730g.	4.5913g.	4.8461g.	4.3397g.	4.7868g.
Total chlorination products, as oxides, in per cent		3.87	30.03	39.37	43.01	56.55
Yield during period "a"	in %	0.204	0.980	1.32	4.58	8.02
	% per min.	0.012	0.057	0.066	0.229	0.321
Yield during period "b"	in %	0.268	8.97	13.42	9.03	11.28
	% per min.	0.008	0.260	0.269	0.301	0.376
Yield during period "c"	in %	0.536	1.290	1.94	2.59	4.70
	% per min.	0.014	0.032	0.060	0.065	0.134
Water soluble residue in per cent (from tube)		2.86	18.79	22.69	26.81	32.55
Ratio of Al_2O_3: SiO_2		....	2.46	2.45	2.40	2.37

TABLE II—CLAY NO. 2

Run / Temperature		A 505°C	B 610°C	C 700°C	D 805°C	E 850°C	F 910°C
Time	a	20 min.	25 min.	20 min.	20 min.	20 min.	22 min.
	b	30 min.	35 min.	30 min.	30 min.	30 min.	25 min.
	c	40 min.	lost	40 min.	40 min.	....	....
Sample weight		0.3359g.	0.7739g.	0.9605g.	2.5528g.	2.7467g.	2.5919g.
Total products as oxides in per cent		0.00	1.56	16.60	39.10	41.54	46.58
Yield during period "a"	in %	0.00	0.49	2.95	3.46	12.18	20.65
	% per min.	0.00	0.02	0.148	0.173	0.609	0.939
Yield during period "b"	in %	0.00	1.07	2.07	20.12	24.59	23.23
	% per min.	0.00	0.03	0.069	0.671	0.829	0.929
Yield during period "c"	in %	0.00	lost	2.20	8.99	stopped	
	% per min.	0.00	lost	0.055	0.225	stopped	
Water soluble residue from combustion tube in per cent		0.00	0.00	9.38	6.53	4.77	2.70
Value of Al_2O_3: SiO_2		....	....	1.66	1.55	1.23	1.27

It will be seen that the ratio of aluminium oxide to silicon dioxide chlorinated is greater than unity, as high as 2.46 in one run with clay No. 1, while in the original clay this ratio is approximately 0.85. In the German Patent of Siemens-Halske referred to before, it is claimed that fairly pure aluminium chloride can be obtained from a silicate by keep-

ing the amounts of carbon and chlorine low enough to react with the aluminium oxide only. While this was not attempted in this experiment, conditions affecting the clay in such a manner may have been introduced.

It is evident that the rate of chlorination of flint fire clay increases rapidly with the temperature. With one exception, run C in clay No. 2, the total yield of chlorides during the middle period "b" was greater than that in the last period "c," even though the latter was from ten to twenty-four minutes longer than the former. It is interesting to note the decrease, however slight, in the value of the aluminium oxide to silicon dioxide ratio with increase in temperature. Apparently temperature is also a factor in the selective reduction within the charge. That the yield during period "b" should have been greater than that during period "c" may have been due to changes in physical condition, such as surface exposure, etc., in the charge during the run.

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USE OF SEDIMENTARY KAOLINS OF GEORGIA IN WHITEWARES[1]

By G. A. Bole[2] and R. T. Stull[3]

ABSTRACT

Introduction.—From twenty-six different clays tested the eleven best suited to the white ware industries were washed and, after preliminary tests were run, were tried out in the different whiteware industries.

Laboratory Tests on Crude Clays.—Tables containing data on the physical properties of the green and burned clays are given.

Laboratory Tests on Washed Clays.—Test bars and color pats were made from a typical whiteware body. The usual physical tests on unburned and burned bodies are reported. Results obtained on the rate of casting and strength of the clays as compared to English and Florida clays are included in the data.

Industrial Application.—Plant practice tests carried out at two floor tile and one wall tile plant are reported. Bodies containing eleven Georgia clays were tried out. Better results were obtained in the vitrified bodies than in the porous bodies. The smaller shapes gave better results than the larger. Tests on general ware and electrical porcelain are in progress. The conclusion is reached that the Georgia sedimentary clays can be used to displace all the china clay in a vitrified tile body but less than half the china clay in plastic bodies. The color of a body is greatly improved by using washed clay and can be further improved by the addition of cobalt stain.

Introduction

Considerable work has been done on the white clays of the lower Appalachian Region.[4] The greater part of this work, however, pertains to the primary clays of the Piedmont Plateau. The work which has been done on the secondary clays of the coastal plain has been largely geological. The outstanding exception is the work of Sproat[5] who made a survey of the mining and washing method used in the Dry Branch district of Georgia. After modifying the washing practice at the plant of the Georgia Kaolin Company to include the use of electrolytes to float the clay and after preliminary tests had been made on the washed clay the refined product was tested under factory practice in dry pressed ceramic bodies.

The work of Sproat in the Dry Branch district having proved of interest to the ceramic industries, it was evident that the availability and character of the sedimentary clays from a larger area should be investigated but in a manner considerably different from that followed by Sproat. A coöperative agreement between the Bureau and the Central of Georgia

[1] By permission Director, U. S. Bureau of Mines.

[2] G. A. Bole, Supt., Cer. Expt. Sta., Bur. Mines

[3] R. T. Stull, Supervising Ceramist, Bur. Mines.

[4] "White Ware Clays East of Mississippi," Stull-Watts-Schurecht (in print). U. S. G. S., *Bull.* **708**—H. Ries, W. S. Bayley and others. U. S. B. M., *Bull.* **53**—A. S. Watts. Georgia State Geological Survey, *Bull.* **18**—O. Veatch.

[5] *Bull.* **128,** U. S. Bur. Mines—Sproat.

Railway Company provided the occasion and necessary funds for an investigation of the coastal plain deposits lying within the State of Georgia. This deposit extends from Fort Gaines on the Chattahoochee River on the west, south of Macon in the center of the state, to Augusta on the Savannah River.

Twenty-six lots of one ton each were shipped from the leading operating mines and undeveloped prospects in this area. These samples included bauxites as well as bauxitic clays and kaolins. After preliminary laboratory investigations which eliminated those kaolins showing too much color as unsuitable for whiteware, the clays which gave promise of producing a whiteware body were washed in thousand pound lots in the whirlpool washer. Electrolyte was used to deflocculate and later to flocculate the clay. Results of the washing of the clays were published in a former paper of this series.[1]

After the clays had been washed, laboratory tests were made leading to information that could be used in connection with the plant practice work which was later to be done.

This presentation (the third of the series) has to do with (*a*) the preliminary laboratory tests on the crude clays, (*b*) the laboratory work on the washed clays and (*c*) the plant practice investigation.

Preliminary Laboratory Tests on Crude Clays

Preliminary laboratory work on the crude clays consisted of making the customary physical tests which included: water of plasticity, drying and burning shrinkage, porosity, color and deformation temperature.

The clay was carefully sampled by quartering the ton sample to a thirty pound sample. This was disintegrated so as to pass a 40-mesh sieve and again thoroughly mixed. A pound of the clay thus prepared was saved for the chemical analysis.

Wet screen analyses were made. The screens used were Tyler standard No. 65, No. 100 and No. 150. Samples from the material on all the screens were saved for microscopic examination.

The material passing the No. 150 screen was made up into bars and disks which were tested to determine color, deformation, shrinkage, porosity, drying and burning behavior. The bars and pats were burned in two sets to cones 01 and 11. Results of these tests are shown in Table II.

The viscosity tests were made by determining the time required for 250 cc. of a 25% slip to flow through a given sized orifice in a Marriott tube after varying percentages of electrolyte had been added. The clay slip was blunged 12 hours before a determination was run. The electrolytes

[1] Stull and Bole, "Washing Tests of Georgia Clays," *Jour. Amer. Ceram. Soc.*, **6** [6], 730 (1923).

used were caustic soda and acetic acid. The results of these tests have been shown graphically.[1]

The clays are classified (see Table I) according to their alumina content alone. A clay containing up to 40% of alumina is classed as a kaolin; the clays containing between 40 and 52% alumina are classed as bauxitic kaolins; and those containing more than 52% are classed as bauxites.

The data presented in Table II need no explanation with the exception of those in the column headed "color." These numbers represent the relative whiteness of the clays under test. The whitest burning clay (No. 1) represents the best of the Georgia clays. The poorest color (No. 10) was a decided brown.

TABLE I

SCREEN ANALYSIS

Clay	Kind of clay	On 65	On 100	On 150	Through 150
G–1	Kaolin	8.58	6.32	1.07	84.00
G–1b	"	.007	.003	.008	99.082
G–2	Bauxitic-kaolin	7.26	2.27	2.17	88.25
G–3	Kaolin	9.54	2.66	5.68	82.11
G–4	"	20.02	2.31	1.77	75.94
G–5	"	1.89	0.90	1.01	98.29
G–6	"	5.26	2.49	6.08	86.15
G–7	"	4.46	2.33	2.17	91.02
G–8	"	1.59	1.03	1.12	96.23
G–9	"	1.96	1.86	2.45	92.11
G–10	Bauxite	26.96	4.22	2.39	66.42
G–11	Kaolin	44.10	5.07	4.66	46.15
G–12	Bauxite	39.62	4.52	5.73	50.09
G–13	Bauxitic-kaolin	39.89	3.06	4.36	52.67
G–14	Bauxite	19.37	3.12	4.09	73.41
G–15	Kaolin	0.22	0.33	0.62	98.83
G–16	"	0.25	0.21	0.16	99.37
G–17	"	0.64	1.42	3.05	94.94
G–18	Bauxitic-kaolin	32.50	4.18	6.96	56.34
G–19	Kaolin	8.08	3.74	2.55	85.44
G–20	Bauxitic-Kaolin	10.38	3.07	3.02	73.51
G–21	Kaolin	0.20	0.14	0.43	99.23
G–22	"	0.45	0.34	0.13	99.07
G–23	"	1.88	1.41	2.43	94.76
G–24	"	1.12	1.29	0.61	96.96
G–26	"	.006	.01	.04	99.89

Laboratory Work on Washed Georgia Clays

It was evident from the preliminary tests on the crude clays that many of the kaolins could not be freed from iron and titania so as to be useful in the whiteware industry because the impurity was present as a stain

[1] Stull and Bole, *loc. cit.*

TABLE II

WORKING PROPERTIES AND FIRE TESTS ON GEORGIA CLAYS

		Crude			Cone 01				Cone 11			
Clay	% H_2O plasticity	% Vol. shrinkage	Drying behavior	% Vol. shrinkage	% Porosity	Burning behavior	Color No.	% Vol. shrinkage	% Porosity	Color No.	Deformation cone.
G–1	41.06	24.83	Good	20.54	35.75	Good	3	40.05	29.20	8	34
G–1b	31.20	20.60	Good	20.90	39.20	Fair	2	44.30	16.50	8	34
G–2	31.76	11.56	Poor	13.83	50.71	Poor	1	25.40	41.25	2	34
G–3	35.76	17.05	Fair	19.98	38.39	Fair	3	42.64	14.07	7	34
G–4	33.60	15.40	Fair	11.76	42.81	Fair	1	35.04	24.41	2	34
G–5	38.50	22.68	Good	13.01	41.37	Good	2	38.01	22.82	3	34½
G–6	44.50	24.97	Fair	14.34	43.47	Poor	2	47.27	12.65	3	34
G–7	35.20	18.71	Good	18.10	40.81	Fair	2	41.88	13.62	5	35
G–8	42.33	28.19	Good	14.46	40.14	Good	3	35.59	16.37	6	34
G–9	38.06	27.40	Good	14.68	42.79	Good	2	69.07	24.48	5	34
G–10	28.60	11.03	Poor	12.06	54.15	Fair	2	44.77	27.77	6	38
G–11	39.66	20.38	Poor	18.36	42.52	Good	3	43.09	24.30	8	35
G–12	29.68	14.49	Poor	13.52	56.24	Good	3	47.10	29.56	7	39
G–13	32.80	7.53	Bad	16.80	49.10	Good	3	45.15	27.05	7	37½
G–14	33.83	12.90	Poor	12.80	36.60	Poor	2	47.87	29.46	4	39
G–15	38.73	15.83	Fair	14.68	44.20	Good	1	37.32	25.72	2	34½
G–16	43.30	20.90	Fair	12.69	46.20	Good	1	36.43	26.96	3	34
G–17	41.90	17.04	Good	12.17	46.44	Fair	2	34.40	28.55	4	33
G–18	28.96	14.21	Poor	16.96	50.20	Poor	7	55.32	24.00	10	34
G–19	42.40	13.34	Bad	bars cracked		Bad	3	52.17	15.51	7	34½
G–20	30.13	11.32	Good	15.20	48.60	Poor	3	44.86	15.93	6	36
G–21	49.50	36.46	Poor	25.09	40.83	Bad	3	44.57	13.94	9	34
G–22	38.33	16.55	Fair	bars cracked		Bad	2	36.65	11.94	6	34
G–23	38.10	26.66	Fair	12.61	38.83	Good	2	32.09	15.03	7	33
G–24	38.23	20.66	Good	15.58	42.00	Good	1	45.04	14.92	2	34
G–26	28.60	16.80	Good	14.60	45.80	Good	1	35.80	23.80	3	34

or was so finely divided that it could not be removed by an elutriation process. Some of these clays after washing when fired to cone 01 gave a good color but when fired to a temperature used in the whiteware industries developed a decided cream tinge. Many of the clays which do not burn to a good white were of excellent color in the crude and will be tested for filler purposes.

The clays which gave especial promise as whiteware clays were the following: G–1b, G–2, G–4, G–7, G–15, G–16, G–24, and G–26.

In order to try out the speed of casting of the Georgia clays in comparison with a body containing English clays a series of tests were made in which cups were cast in a plaster mold and the weight of the cups after drying recorded. The data obtained on the Georgia clays together with a similar body containing English and Florida clays are given in Table III. The clays were all made up with sufficient electrolyte (50% Na_2SiO_2—50% Na_2CO_3) to produce maximum fluidity in a 40% body—60% water mix. The body mixes were the same as those used in the other tests.

Practically all the cups, except those containing the English clay, cracked upon drying.

TABLE III

WORKING PROPERTIES AND FIRE TESTS ON BODY CONTAINING GEORGIA CLAY

The test body on which the tests were run using the washed clays was the following:

Feldspar	25 Per cent
Flint	25 " "
Ball Clay	5 " "
Test Clay	45 " "
	100 " "

	Water of plasticity	Drying shrinkage (vol.)	Casting wt. of cup	Cross breaking strength, lbs. sq. in.	Cone 5½ Porosity	Cone 5½ Shrinkage vol.	Cone 5½ Color	Cone 12 Porosity	Cone 12 Shrinkage vol.	Cone 12 Color
G–1b	25.2	13.2	65.2	8.2	16.3	22.1	3	2.30	28.8	3
G–2	25.8	7.17	70.1	7.4	20.4	24.0	2	6.39	30.9	3
G–4	24.8	12.16	60.1	11.3	14.5	21.3	2	2.80	31.6	2
G–7	26.3	15.37	63.5	10.8	15.4	23.8	4	.32	28.0	4
G–15	28.5	21.55	64.2	10.2	16.7	21.3	2	2.33	28.9	3
G–16	28.4	18.20	63.1	9.4	20.5	20.6	3	3.68	28.6	3
G–24	27.2	17.82	65.2	15.6	14.2	23.2	4	.11	30.9	4
G–26	26.0	14.80	68.1	12.0	16.4	22.4	3	2.12	29.4	3
E			62.5	8.9						
F			46.9	23.6						

Cross breaking strength tests on solid bars made by pouring the slip into a 1″ x 1″ x 6″ mold were made. Results given in Table III represent the number of pounds necessary to break one of these bars at the center, the bar being supported on a 5″ span by knife edges.

The Plant Practice Tests

General Ware and Electrical Insulators.—Commercial tests of several of the clays are being made. About five hundred pounds of the clays G–2 and G–15 (washed) were sent to a pottery in the East Liverpool district to be made into tableware. The body into which it was to be incorporated is a semi-porcelain. The body will be made up into three hundred pieces of ware in the ordinary plant procedure; some will be cast, others jiggered, and all then dried, burned, glazed and decorated in the regular way.

One hundred pounds of a high tension electrical porcelain body was prepared at the Columbus Station of the Bureau of Mines, consisting of feldspar, 19.25; whiting, 2.26; flint, 38.60; ball clay, 20.00; test kaolin, 20.00; and sent to a plant at East Liverpool where it will be made up into insulators by the semi-dry press process and tested for di-electric strength. The body mix was as follows:

The plant tests have as their aim the gathering of reliable data on the adaptability of the Georgia sedimentary clays to the plastic and dry press processes. Due to the fact that the potters' strike seriously interrupted production at the time and due later to the urgent demand for quantity production the results of the tests are not yet at hand. A complete report on the tableware and electrical porcelain tests will appear later.

Wall and Floor Tile.—Several of the clays were run through plant practice in floor and wall tile bodies at Zanesville, Ohio, and Olean, New York. Clays G–2, G–4, G–7, G–15, and G–16 were used in floor tile and G–2, G–7 and G–16 were tried out in wall tile bodies.

As a preliminary survey the body compositions first tried in wall tile were as follows:

	(1)	(2)
Cornwall Stone (Eureka)	12.0	....
Tenn. Ball Clay No. 7	12.0	8.0
Cooley Ball Clay	12.0	8.0
Clay (Experimental)	30.0	36.0
Flint	34.0	36.0
Feldspar	....	12.0
	100.0	100.0

Seventy-five pound batches of these bodies were blunged for four hours and screened through a No. 140 screen. The slip was continuously agitated until it was run into the presses where it was subjected to a pressure of 90 pounds. All the bodies filtered easily and formed good firm cakes. The cakes were dried and pulverized to pass 40 mesh.

The tile were made in two sizes, 6″ x 6″ x $^{15}/_{32}$″ and 6″ x 3″ x $^{3}/_{8}$″, under a pressure of 50 pounds per square inch in a steam press. The bodies containing G–7 and G–16 pressed very well and no loss occurred in the handling and trimming, but the body containing G–2 was very weak and broke easily in the "green" state. The moisture content for all the bodies was approximately nine per cent.

The tile were air dried and fired in up-draft kilns to cone 11 to 12 which were placed inside the saggers.

The 6″ x 6″ tiles received a temperature treatment corresponding to the deformation of cone 11, while the 3″ x 6″ tiles were fired to cone 12. The bisque was then dipped in a clear glaze and fired to cone 1.

All of the tile fired satisfactorily but the 6″ x 6″ size cracked badly during the bisque fire. No additional cracks developed during the glost burn. The large shapes made from the body containing G–2 behaved particularly badly in the bisque burn. This is a peculiar clay which seems to have the working properties of a kaolin, but is above the kaolinite ratio in alumina.

When the data had been examined it was found that these clays varied widely in degree of vitrification and consequently in shrinkage and porosity at cone 11. It was therefore decided to blend the clays in an endeavor to get a body with approximately the shrinkage and porosity desired in the industry, *i. e.*, 13% absorption and not more than 5% shrinkage at cone 11.

The percentage of ball clay was lowered in the second set of tests as the Georgia clays are themselves quite plastic. The flint was raised in three cases somewhat in an endeavor to open up the body. Furthermore, the second set of trial bodies was more thoroughly blunged than was the first set. In no case, however, was time allowed for the moisture thoroughly to permeate the dried powder prior to pressing.

The bodies used for the second set of tests were as follows:

COMPOSITION

	(1)	(2)	(3)	(4)	(5)	(6)
Feldspar.....	12.0	12.0	12.0	12.0	12.0	12.0
Tenn. Ball Clay No. 7.....	8.0	8.0	8.0	7.0	7.0	7.0
Cooley Ball Clay	8.0	8.0	8.0	7.0	7.0	7.0
Clay (Experimental).....G–7	36.0	G–7 18.0	G–7 27.0	G–7 36.0	G–7 18.0	G–7 27.0
		G–16 18.0	G–2 9.0		G–16 18.0	G–2 9.0
Flint.....	36.0	36.0	36.0	38.0	38.0	38.0
	100.0	100.0	100.0	100.0	100.0	100.0

PHYSICAL PROPERTIES

	(1)	(2)	(3)	(4)	(5)	(6)
Shrinkage (linear).....	7.0	5.6	5.0	6.8	5.5	4.8
Absorption.....	11.7	9.2	13.0	11.7	10.5	15.8
Color.....	C	A	B	C	A	A

The bodies used in the second set of tests were prepared and pressed in the same way as in the first with the exceptions already noted.

The bodies worked equally as well as in the first tests and developed no cracks during drying. When the ware had been drawn from the bisque kiln it was found that the cracking had been decreased, but not eliminated, especially in the case of the larger pieces.

As the dies used were made with allowance of 4% shrinkage, the tiles made from the Georgia clay were all under size. The commercial ware was fired (cone 11) to 13% absorption, hence body No. 3 had approximately the desired absorption and not an excessive shrinkage. The 6″ x 3″ tile of this composition passed the plant test 80% perfect; the 6″ x 6″ went through 40% perfect.

The plant tests on wall tile were then discontinued. Later tests at the Station indicated that, by blending the clays in the proper ratio and using the blend to less than 20% kaolin in a body already containing 15% of a primary kaolin, good results can be expected. Such a body is to be tested under plant practice in the near future.

Conclusions on Wall Tile Tests.—The tile in no case showed a tendency to warp. There were no specks visible in any of the specimens except those introduced by tramp iron, this indicates that the cyclone washing was effective in eliminating a serious objection raised against Georgia kaolins.

The color of the glazed ware made from the different clays was, in order of whiteness, G–2, G–16 and G–7. The color of the tile made from G–2 and G–16 while not as chalk white as one or two of the commercial makes (which may have contained blue stain) is, nevertheless, in every sense of the word good whiteware. The tile made from G–7 had a slight ivory tinge but was as good a white as several of the commercial wares. No blue stain was used in the trial bodies.

About 20% of properly blended mix of the Georgia sedimentary kaolins can doubtless be used in wall tile bodies, but inasmuch as these kaolins are almost lacking in free silica, the flint should be increased accordingly.

The sedimentary kaolins as prepared by Sproat[1] were tested under plant practice in the wall and floor tile industries where they are reported to have given satisfactory results.

Floor Tile.—Two floor tile bodies were tested under regular plant practice. Body (A) was prepared in the same manner as were the first wall tile bodies. Body (B) was weighed and ground wet in a test mill, after which it was filter pressed. From this point on the process was identical with the regular plant practice.

Five clays in all were tested. Three in body (A): G–2, G–7 and G–16; and two in body (B): G–4 and G–15.

Compositions of the vitreous floor tile bodies were:

Body A		Body B	
Erwin Feldspar	45	Feldspar	40
Flint	15	Flint	20
Clay (Experimental)	30	Clay (Experimental)	30
Kentucky Ball Clay No. 4	10	Tenn. Ball Clay	10
		Heavy MgO	1

Body (A) was molded in two sizes—one inch hexagons and $2^1/_6''$ x $2^1/_8''$ x $^1/_2''$ shapes. The dust was pressed in hydraulic presses under a pressure of 2000 and 1600 pounds, respectively. No loss occurred due to handling or trimming. Body (B) was pressed into shapes $^1/_2''$ x 1" x $^1/_2''$.

[1] Sproat, *loc. cit.*

The tile made from body (A) was air dried and burned in saggers to cone 12 in an up-draft kiln. The ware came from the kiln in perfect condition. There were no losses from warping or cracking. The tiles with G–7 and G–16 showed greater vitrification than did the regular body and the color with these was not quite so good as that of the regular ware. G–2 body was very white and compared favorably with the regular product. All tile made from the different bodies showed zero absorption.

The results on G–4 and G–15 made into body (B) following the same practice as was used in the manufacture of body (A), from the point where the dust was pressed, gave even better results as they were burned to cone 10 to 11 instead of cone 12. The color was somewhat better than that of tile made from G–7 and G–16. They were also whiter than the regular commercial ware made at the plant. The surface finish was not so good, however, as the commercial ware due, no doubt, to the fact that the body was prepared in small batches and not as well granulated as the regular body prepared mechanically in large batches. Some of the commercial body was also prepared in the same manner and put through the process in every way to correspond to the bodies under test. The commercial body lacked the gloss which it has when prepared in the regular way. Both the floor tile bodies made from Georgia clay were whiter than the commercial bodies so made.

There was no loss in the floor tile bodies made from the Georgia clays due to drying or burning at either plant. All five clays are well suited to use in vitrified tile manufacture.

Discussion of Results

The use of Georgia (sedimentary) kaolins in the several whiteware industries is no novelty. They have been used in practically every type of pottery body, both dry press and plastic, where a china clay is required. In some cases they have been used very successfully while in others their use has been discontinued due to various reasons more or less warranted.

Their use has been abandoned by some chinaware manufacturers principally because of lack of uniformity. Many of the clays burn to a good white, while many others which burn to a cream color could be produced white enough to meet requirements if the proper care were taken in their mining and refining. However, some of the clays are so stained with colloidal iron oxide that their color cannot be improved by washing. Bleininger states that the slight variation from white shown by these clays can be corrected by the use of cobalt stain. The bulk of the Georgia clays are produced for the filler trade where whiteness in the raw state is all important and the burning color is of no consequence. A more serious effort should be put forth by the producers to cater primarily to the pot-

tery trade by producing in quantities, uniform as to color and working properties.

These clays have been used quite extensively in the sanitary tile and electrical porcelain industries. Some manufacturers have not used Georgia sedimentary kaolins in these wares because in the trials made, black specks developed during the firing. The tests just completed on clays washed at the Ceramic Station prove that the latter difficulty can be overcome by proper washing.

A serious problem in connection with the use of sedimentary clays is probably the high bisque loss and excessive shrinkage. These difficulties can, it seems, be overcome by proper body mixes and by the blending of the clays. These clays analyze close to theoretical kaolinite in alumina and silica. They, therefore, contain almost no free silica and bodies containing them require a higher flint content than bodies containing primary kaolins. A higher flint content improves whiteness.

Georgia clays, as pointed out many times, are very different from English clays in physical structure and to a less extent in mineralogical constitution, hence cannot be expected simply to displace the English clay in a ceramic body. It is a peculiar fact that no one ever suggests substituting entirely Florida for English clay, but to the writers' knowledge Georgia clays have been condemned in many cases because they will not substitute pound for pound in a plastic body for the imported clay. Florida clays have been used judiciously and have gained a reputation for possessing two very desirable qualities, namely: workability and strength. On the other hand they do not cast so rapidly as do the best Georgia or English clays. The more desirable Georgia clays cast as rapidly as do the English china clays and improve the workability of the mix nearly as well as do the Florida kaolins.

Conclusions

As indicated by tests made in two commercial plants, washed Georgia clays can be used to advantage to displace all of the English china clay in a vitrified dry press body of small size such as floor tile.

The washed clay can be used to displace a portion of the china clay in a porous dry press body such as wall tile up to about 20% of the batch. However, the extent to which the displacement may safely be carried depends largely upon the shape and size of the ware.

The amount of the sedimentary clays that can be used in plastic bodies is much less than in a press body and should probably not exceed 10 to 15% of the batch. The amount will vary with the ware being manufactured.

The proper blending of the clays together with judicious body mixes will render the Georgia clays much more available for whiteware purposes.

An increase in flint in bodies containing Georgia clays is essential to obviate crazing of the glaze, reduce shrinkage and incidentally to improve whiteness.

The color of ware made from a properly washed clay is about equal to the usual grade of china clay and it is only slightly inferior to the highest grade of English clay and domestic primary kaolins.

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CERAMIC ABSTRACTS

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Art

1. Zircon for white glazes. P. P. BUDNIKOV. *Tonind. Ztg.*, **47,** 173–4(1923).—Sn for the production of opaque glazes is becoming too expensive and difficult to get. Antimony (Sb_4O_6) produces opaque glazes with good color and gloss. Arsenic (As_2O_3) produces beautiful transparent white glazes and also opaque white glazes but they are not very durable and are destroyed by firing at high temps. A glaze contg. bone ash develops a scum on the surface. The best products are produced with cryolite. In order to get a better bond between the glaze and body small amts. of zinc oxide (ZnO), lime (CaO), etc., are added. The glazes produced with zircon compds. are much more dependable. 5% of the oxide of zircon (ZrO_2) gives a thorough white opaque glaze. Still better results are obtained with a mixt. of tin oxide (SnO_2) and a zircon prepn. By the introduction of ZrO_2 in the glaze the m.p. is raised. It was found that when the Sn and Zr are introduced as hydroxides they have a better covering power. This is due to the fact that the hydroxides are finer grained. The following glazes were used by B.:

Glaze 1		Glaze 2	
Oxide of zircon	5	Oxide of tin	7
Red lead	24	Oxide of zircon	3
Kaolin	10	Red lead	32
Soda ash	14	Silica	35
Calcium carbonate	1	Kaolin	10
Zinc oxide	1	Soda ash	12
Silica	35	Zinc oxide	1

H. G. S.

2. Note Books of Josiah Wedgewood. BERNARD MOORE AND J. W. MELLOR. *Pottery Gaz.*, **48,** 619–26(1923).—Quotations from original manuscripts of Josiah Wedgewood are given and they show that many ideas considered modern were worked out carefully as far back as 150 yrs. ago. J. W. H.

3. The romance of pottery. F. A. RHEAD. *Pottery Gaz.*, **48,** 626(1923).—An address. J. W. H.

4. Uranium glazes. MIKIYA AKATSUKA. *Rept. of the Pottery Lab.* (Kioto), **1,** 57–73(1922).—*1. Vermilion glaze.* Raw glaze (b) composed of 35 white lead, 10 quartz and 8 ammonium uranate, $(NH_4)_2U_2O_7$, has produced a brilliant vermilion at cone 012a–011a. An addn. of Funori glue is recommended. It was applied 3 times as thick as ordinary porcelain glazes on vitrified porcelain biscuits. *2. Red glaze.* Replacing 1 part of the uranate with 1 part of ferric oxide in the glaze (b), a brownish red was obtained. *3. Crystal and luster.* The appearance of the glaze (b) changes with firing temp., thus:

Cone	012a	01a	1a	1a–2a	5a	8–9
Fuel	wood	coal	wood	coal	coal	coal

Color of glaze	vermilion	reddish orange	blackish brown	reddish brown blackish brown or reddish orange	yellowish green vermilion or blackish red	blackish brown
Color of crystal	.....	....	gold	crimson or green	green	....
Color of luster	.....	....	....	.....	greenish purple	gold or purple

4. Crystal glazes. The following table shows glaze batches and temperatures at which crystal glazes were developed:

Glazes	P	Q_1	Q_2	R	S
White lead	70	75	75	70	70
Ammonium uranate	16	15	15	15	16
Quartz	20	19	16	18	20
Rutil	7	7	8	3	..
Cobalt carbonate	..	0.5	1	..	0.5
Zinc oxide	..	..	..	5	..
Cone	5a,6a	5a	5a,6a	5a,8	1a

When a flower vase was glazed with R, set in a sagger which was coated with a glaze composed of 37 white lead, 8 quartz and 11 ammonium uranate, and burned to cone 5a, very fine golden small crystals were developed on bright glaze of same color.

S. KONDO

Cement, Lime and Plaster

5. Reagents used in etching cement clinker for the examination of its microstructure. The microscopic study of cement clinker. III. TAKEHIRO HATTORI. *Rept. Indus. Dept. Central Research Lab.* (Govt. of Formosa), **1**, 1–6(1922).—Thin sections of clinker can not be easily prepd., owing to its porous and friable nature. Therefore, a method which consists in polishing a single surface of the specimen, developing the structure by etching with a suitable reagent, and examg. under vertical illumination is usually used. Water and dilute soln. of HCl in alcohol have been recommended as the reagents. The author has tried other reagents for the purpose. Generally speaking, the sections of Port. cement clinker consist of cryst. grains (alite) and filling substances. The filling substances do not react uniformly with etching agents. Some portions of the filling substances in polished but unetched sections look gray under vertical illumination and are easily etched, while other portions are white and resist reagents better than the former. Eutectic structure is frequently observed in the filling substances. There are also grains which resemble alite but show different resistance to reagents. White substance was not attacked by water even when the section was immersed for 24 hrs. in it. Soln. of cane sugar retards the setting of the cement when its concn. is weaker than 0.5%, while it accelerates the setting when its concn. is stronger than 1%. When sections were treated with the 0.2% soln. for 5 min. the eutectic structure in the gray substance was distinctly developed as white spots. When sections were treated with the 10% soln. for 5 min. grains resembling the cryst. ones appeared. The author considers them as free lime. In conclusion, the author recommends the use of am. oxalate or am. sulphate for examg. distribution of alite crystals and the use of calcium chloride or cane sugar for the observations of gray substance. S. KONDO

6. Effect of aeration on the properties of Portland cement. TAKEHIRO HATTORI.

Rept. Indus. Dept. Central Research Lab. (Govt. of Formosa), **1**, 7–24(1922).—Influence of aeration of 4 Port. cements on market upon their various properties are described. The aeration was effected by spreading the cement in a shallow box and turning it over once a day. *1. Loss on ignition.* Loss on ignition increases with the time of aeration. A cement has shown 0.64%, 1.72%, 3.90%, 5.74%, 8.23% and 10.74% ignition-loss at the end of 0, 1, 4, 8, 13 and 20 weeks, respectively. *2. Constancy of volume.* Linear expansion of test pieces made of a cement with Le Chatelier's mold was measured by immersing them immediately in water. The average increase in length after 24 hrs. was as follows:

Time of aeration	0	3 days	2 weeks	4 weeks	8 weeks	20 weeks
Expansion in mm.	0.7	0.3	0.6	0.3	0.1	0.1

3. Time of setting. Aeration first retards the setting, then accelerates it and a further aeration retards it again. *4. Strength.* In general, the strength of a cement is decreased by aeration. Besides, tables and curves showing heat evolved in setting are shown. The author discusses the influence of free lime on various properties of the cements. S. KONDO

7. Slag cement and dolomitic cement. SABURO KIMURA. *Central Research Lab.* (The South Manchurian R. R. Co.) *J. Jap. Cer. Assn.*, **364**, 595–608(1923).—*A. Slag cement.* Tensile strength of numerous mortars composed of granulated blast-fur. slag of the Anzan Iron works or the Honkeiko Iron Works, Portland or natural cement, slaked lime and sand have been studied. To cite some of the results on the Anzan slag which was ground to pass through a sieve with 2500 meshes per sq. cm. and contained 36.97 sol. silica, 1.08 insol. matter, 11.86 alumina, 0.40 ferric oxide, 44.83 lime, 2.52 magnesia, 0.66 sulphuric anhydride and 1.64 sulphur, we have:

Propn. in wt.				Tensile strength, kg./sq. cm.			
Slag	Port. cement	Sand	Seawater per cent	7 days	28 days	3 months	6 months
...	1.0	3.0	8.3	15.3	20.0	23.4	25.8
0.9	0.1	3.0	8.8	8.0	22.4	24.5	26.0
0.8	0.2	3.0	8.3	8.4	22.5	25.8	26.0

Slag accelerates setting of Port. cement, thus:

Propn. in wt.			Setting time, hour, min.		
Slag	Port. cement	Fresh water per cent	Temp. in °C	Initial set	Final set
...	1.0	25.0	20.5	6.04	9.52
0.7	0.3	43.0	20.5	1.12	6.03

B. Dolomitic cement. Tensile strength of dolomitic cements which were prepared by calcining four kinds of Manchurian dolomite for several hrs. at 600–700°C and then by grinding them to pass through a 900-mesh sieve was tested. The strength and hydraulicity increase with its content in sol. silica. Some of the results obtained with a dolomite contg. 19.14 sol. silica, 0.66 insol. matter, 1.10 alumina and ferric oxide, 27.74 lime, 22.41 magnesia and 28.34 loss on ignition are as follows:

Propn. in wt.					Tensile strength, kg./sq. cm.	
Calcined dolomite	Port. cement	Calcined pegmatite	Anzan slag	Sand	14 days	28 days
...	1.0	...	...	3.0	17.9	25.0
1.0	...	...	...	3.0	6.9	15.0
0.9	0.1	...	...	3.0	6.9	11.9
0.9	...	0.1	...	3.0	8.1	12.5
0.9	...	...	0.1	3.0	15.0	19.4

Thus, dolomitic cement with small addn. of blast-fur. slag is a good hydraulic cement and can be used as a substitute for white Port. cement, as it can be prepd. nearly pure-white. S. KONDO

8. Fast hardening cements. (Fused cements.) ANON. *Rev. Mat. Constr. Trav. Pub.*, **162,** 49–52(1923).—Fused cement is made from limestone and bauxite (silicate of alumina) by heating the mixt. in a fur. till liquefied, and running it out to cool and solidify. The mass is crushed and then ground very fine, analyzing in per cent, SiO_2 10, Al_2O_3 40, Fe_2O_3 7, CaO 43, as compared with Port. cement SiO_2 22–23, Al_2O_3 6–7, Fe_2O_3 2–3, CaO 57–66. Fused cement sets slowly but afterwards hardens rapidly, the setting beginning to take effect 3 hrs. after mixing, and complete in 4–8 hrs., behaving like Port. cement. The setting of fused cement alone is accompanied by a great evolution of heat. The rapid hardening is illustd. by the fact that in a mortar the fused cement gains its full strength in 18 hrs., whereas it takes a month for the Port. cement.

Tensile strength	Kgms. per sq. cm.				
	18 hr.	2 d.	7 d.	28 d.	3 m.
Pure cement	..	..	..	..	..
Fused cement	39	62	68	77	77
Portland cement	..	25	48	52	56
1:3 mortar	..	..	..	..	..
Fused cement	38	41	43	40	39
Portland cement	..	14	28	35	37

For concrete mixts. of 1 m.^{3} of gravel, $^1/_2$ m.^{3} of sand, and varying quantities of cement the compression strengths are:

Concrete made with	Hectopiezes[1]				
	24 hr.	48 hr.	7 d.	14 d.	28 d.
Fused cement 150 kgms.	77.2	71.2	73.5	..	..
Fused cement 200 kgms.	93.7	145.1	152	..	..
Fused cement 250 kgms.	214.5	194.6	191.1	..	..
Port. cement 250 kgms.	...	22.1	57.1	93.7	82.7

[1] The Hectopieze is the authorized unit of pressure, 1.02 kgms. per sq. cm.

Action of gypsum. The screened hardened cement when mixed with $^1/_2$ of its wt. of gypsum and moistened does not swell, whereas Port. cement treated in a similar manner decomposes and swells to many times its size. LOUIS NAVIAS

9. New facts about "ciment fondu." ANON. *Rock Products*, **26,** 29(1923).—A series of tests of this quick-setting cement, which is a French product, were conducted recently by the Boston Elevated Ry. Co., the results of which are tabulated below. 3 well-known brands of Amer. cement and the specifications of the A.S.T.M. for 1921, were used in the comparison with "*ciment fondu.*" 3 different mixes of "*ciment fondu*" were used. Figs. were obtained on the amt. passing through a No. 200 sieve, the time of initial set and final set, the strength of the French cement after 24 hrs., the strength of all cements of the 1 to 3 mix after 7 and 28 days, and the results of a 5-hr. boiling test. Sep. tests were made of the one-to-two and one-to-one mixes of *ciment fondu.* From the results it will be noted that the French cement obtained a strength in 24 hrs. greater than any of the standard cements did in 7 days and that the 7 day test of the French cement is greater by 15% than the 28 day test of the others. On the 28 day

TABLE I

COMPARATIVE TESTS OF 1–3 MIXTURE

Make	Initial set	Final test	Per cent passing No. 200 sieve	24-hr. tensile	7-day tensile	28-day tensile
A.S.T.M.	0.0 hr. 45 min.	10 hr. 0 min.	78	...	200	300
"A" Brand	2 hr. 40 min.	6 hr. 10 min.	85.2	...	348	377
"B" Brand	2 hr. 50 min.	5 hr. 40 min.	85.4	...	271	300
"C" Brand	3 hr. 20 min.	7 hr. 25 min.	85.0	...	282	356
French	3 hr. 5 min.	6 hr. 20 min.	96.4	376	423	...

COMPARATIVE STRENGTH OF DIFFERENT MAKES OF CIMENT FONDU

Mixture	24-hr test	7-day	28-day	Per cent of strength
1 cement 3 sand	376 lb.	423 lb.	407 lb.	4.0
1 cement 2 sand	578 lb.	725 lb.	671 lb.	7.25
1 cement 1 sand	685 lb.	1,112 lb.	1,178 lb.	3.0

test it showed a slight loss in strength compared with that at 7 days. This cement, however, did not stand up well under the 5-hr. boiling test, as it cracked and scaled.

O. P. R. O.

10. Setting of Portland cement. BRIT. PORT. CEMENT RESEARCH ASSN. *Pamphlet*, **1**(1922).—This pamphlet gives the results of investigations by the Brit. Portland Cement Assn. into the cause of changes in the setting time of Port. cement. The summary of results is as follows: *Storage of cement out of contact with air.* 6 diff. samples of commercial cements, and 1 sample of pure cement (prepd. from rotary clinker without any addn. of water, steam or gypsum) when kept in sealed bottles for 4 and 6 mos., retained their original character of setting time, were unaffected by fluctuations of temp., and were independent of light or darkness, or the presence or absence of added gypsum. Exposure of cements to gases: (*a*) Pure dry air, oxygen and ozone had no effect on the setting time. (*b*) Moist air, oxygen and ozone retarded the set of all cements. (*c*) Dry carbon dioxide accelerated the setting time. (*d*) Moist carbon dioxide accelerated the set enormously, the character of the cements being entirely changed. All the above results were independent of the presence or absence or added gypsum. (*e*) Ordinary unpurified air had an uncertain effect on setting-time. 3 cements were quickened to a more or less degree, 2 were hardly affected, and 1 was somewhat slowed. In each case the effect on setting-time could be traced to the relative percentages of carbon dioxide and water absorbed or lost. (*f*) Exposure of the same sample of cement first to moist air (free from carbon dioxide) and afterwards to carbon dioxide, resulted in the setting time being first retarded and then accelerated. *Effect of addition of salts.* (*a*) The carbonates of soda, potash and ammonia accelerated the setting-time, the first 2 very strongly. (*b*) Sulphates, in general, accelerated the set. Except gypsum and small propns. of plaster of Paris, very few sulphates had a retarding effect and these all contained water of crystn. (*c*) Chlorides also, as a rule, accelerated setting-time, but the effect was, generally speaking, not very pronounced. (*d*) Nitrates, generally, had no very definite effect. (*e*) The hydroxides employed, including slaked lime, all accelerated the set of cements to a greater or less degree. (*f*) Borax had a similar effect, especially the crystd. salt. *Effect of crystd. water in salts.* (*a*) Anhydrous sodium carbonate, whether dissolved in the gaging water, or ground with the cement beforehand, had a strong accelerating effect on setting-time. (*b*) Crystd. sodium carbonate, dissolved in the gaging water, had a similar action. (*c*) Crystd. sodium carbonate, ground with the cement 24 hrs. beforehand, had considerably less action in quickening the setting-

time. (*d*) Anhydrous sodium carbonate ground with the cement 5 to 9 weeks before testing, greatly accelerated the set. (*e*) Crystd. sodium carbonate, ground with the cement 5 to 9 weeks before gaging, but little affected the setting of the cement, its slow-setting character being retained. (*f*) Quick-setting (ignited) cement, in contact for 6 hrs. with crystd. sodium sulphate or crystd. magnesium nitrate under pressure, became very slow-setting. (*g*) Cement, already slow-setting, was less affected by crystd. water expelled by pressure, but nevertheless absorbed a propn. of the crystd. water and became slower. *Summary of conclusions.* (1) The setting time of cement does not change of itself, even after prolonged storage out of contact with air. There is, therefore, no apparent spontaneous alteration in chemical composition or physical structure. (2) The time of set of cement appears to depend upon the proportion of combined water present in hydrated calcium aluminate or silicate, which tends to form a protective sheath or coating round the particles of cement and resists or delays the penetration of water to the active core. The greater the quantity of water absorbed by, or combined with, the cement, the more impervious is the protective sheath or film and the slower is the time of set. On the other hand, the setting is accelerated by any influence which abstracts water from the cement, or which attacks and destroys or modifies the sheath of hydrated material, thereby enabling the gaging water to penetrate more quickly to the active core of the particle. (3) Changes of setting-time (as when cement is stored) are brought about only by outside influences—*e. g.*, carbon dioxide and water vapor or active salts, which abstract water from, or act upon the protective sheath of hydrous material coating the grains. (4) Cement is capable of abstracting water from salts containing water of crystn. with which it lies in contact for some weeks. Such abstracted water hydrates the cement particles and retards the time of set. (5) Cement, in contact with salts containing water of crystn. which have part of such water expelled by pressure will under these conditions combine with the expelled water and become slower-setting. (6) The setting-time of cement, resulting from the partial hydration of the particles, remains unchanged provided the material is not subjected to outside influences which affect the hydrous film coating the grains. (7) The reason for the acceleration or retardation of setting-time by sol. salts is not sufficiently clear to warrant a definite conclusion being drawn as to whether the action is catalytic or not. In some cases, chem. reaction undoubtedly occurs (*e. g.*, with ammonium salts, and ferric sulphate) and it is reasonable to surmise that the action in other cases is also chemical. It does not, however, appear that the alteration in setting time, brought about by the addn. of salts, is directly due to the formation of double salts, except perhaps when the double sulphate of lime and alumina is formed. In several instances the effect on setting-time appears to be clearly dependent upon the presence or absence of crystd. water in the salt used. (8) The results of this research lead to the conclusion that the use of gypsum as a retarder is sometimes uncertain and irregular in its effects. On the other hand, the regulation of setting-time by hydration, through the medium of steam or water appears to be more permanent. In practice, the regulation of setting time by hydration alone is not generally adopted by manufacturers and some further investigation as to the relative advantages of gypsum and water (or steam) as hydrating agents is desirable.

O. P. R. O.

11. Magnesium oxychloride cements. M. Y. Seaton. *Chem. Age* (N. Y.), **31**, 17–22(1923).—Mg oxychloride cement was originally made by Sorel in 1867. It is important as a binding material because it attains high strength at an early age even with free exposure to air. It does not exhibit a high vol. change due to temp. changes or other causes. The raw materials, mfg. process, selection of suitable aggregates, and the use of oxychloride cements are discussed. Cf. *Ceram. Abs.*, **1** [7], 192–3(1922).

J. C. W. (*C. A.*)

12. Physical properties of dental cements. II. PAUL POETSCHKE. *Ind. Eng. Chem.*, **15**, 339–42(1923); cf. *C. A.*, **10**, 1226.—Methods and app. are described for detg. the heat generation, texture, permeability and setting time of Zn oxyphosphate cements. The heat generated in setting varies considerably in different brands. The heat can be varied greatly by the rate of addn. of powder to liquid and the time of mixing. By proper mixing no brand should cause damage. Crushing strength is directly proportional to heat generation, cements evolving the most heat having the highest crushing strength as well as the finest texture. The texture varies from fine vitreous to coarse chalky. The latter texture is the more permeable to aq. fluids. Cements of fine vitreous texture are impermeable to dye solns. Com. designations for hardness such as "slow," "rapid," etc., are of slight significance, for there is recognized no standard time of set. A cement setting at room temp. relatively faster than another may be relatively slower at body temp. Those showing the greatest strength, the finest texture, the least permeability and the greatest heat liberation on setting show the greatest increase in strength between the 15-min. and 24-hr. period of setting. The ideal cement should set slowly at room temp. and rapidly at body temp. C. C. D. (*C. A.*)

13. Thermochemical research on cement. R. NACKEN. *Zement*, **11**, 245–7, 257–8(1922).—N. deals with the drying of cement in rotary driers at about 500°, the expulsion of CO_2 at 900°, incomplete burning between 1000 and 1250°, in which stage exothermic reactions occur, burning at 1250°, and finally strongly burning at 1400° or higher. The development of heat in the burning of cement is slow below the stage at which CO_2 is expelled. The heat of reaction begins to increase slowly at 930° and rises from 120 to 500 cals. per g., then more slowly to 600 cals. per g. The max. is at about 950°. As soon as the CO_2 is expelled, a vigorous reaction occurs, *i. e.*, the formation of Ca silicates and aluminates, this reaching a max. at 960°, after which equil. is very quickly reached. Different results obtained in tech. practice are due to heterogeneity of the raw materials and the fact that some Ca carbonate has escaped burning until the end. It is calcd. that the quantity of heat required to burn 1 kg. of clinker up to a temp. of 1400° is about 900 cals. J. S. C. I.

14. Improvements in the manufacture of magnesia cement. B. HAAS. *Chem.-Ztg.*, **46**, 88–9(1922).—Crude $MgCl_2$ liquors contg. KCl, NaCl, and $MgSO_4$ so often used in making MgO-$MgCl_2$ cement make a product which dries more slowly, has less hardness, discolors more easily and requires more mechanical treatment but shows less blowing and sweating than one made from a pure $MgCl_2$ soln. of the same concn. Because of such properties and the greater cost of transport of liquor, the relative economy of the 2 methods must be calcd. for each case. Pure $MgCl_2$ solns. for a given purpose should be made 2–3° Bé. less concd. than the proper crude liquor. $MgSO_4$ is of advantage in preventing discoloration and blowing, particularly if weathering occurs under warm and dry conditions. Because of its cost, $MgSO_4$ can be replaced by by-product kieserite. This has proved so efficient that all $MgCl_2$ has been replaced by kieserite and the product is non-hygroscopic and free from blowing, though the rate of drying and hardening is slower and the strength and toughness are less. By replacing $MgCl_2$ by 15% more than its equiv. wt. of kieserite, a product is obtained with satisfactory tenacity. Replacement of part of the $MgCl_2$ by metallic salts, particularly Fe salts, gives a product with less blowing and sweating and with toughness, color and good hardening qualities. Fe salts can also be used advantageously with $MgSO_4$ or with kieserite to obtain pleasing colors. C. C. D. (*C. A.*)

PATENTS

15. Plaster or cement. H. S. THATCHER. Can. 228,860, Feb. 20, 1923. Finely divided kieselguhr is mixed with finely divided calcined gypsum. (*C. A.*)

16. Hardening plaster, mortar or cement containing lime. J. PELC. U. S.

1,447,568, Mar. 6. A mixt. of NaH sulfate and CaF_2 is added to accelerate hardening. (*C. A.*)

17. Waterproofing reagent for concrete. SEI OKI. Japan. 40,198, Oct. 4, 1921. Pptd. residue obtained from soy-bean oil is partly sapond. and $BaCl_2$ soln., kieselguhr and $Al(OH)_3$ are added. The product is dild. with H_2O and used for mixing cement for concrete, etc. (*C. A.*)

18. Fibrous wall-board. J. H. CAFFREY. U. S. 1,447,708, Mar. 6. A mat of loose fibers is coated with a liquid cement, the fibers are sepd. in places to form openings and the material is then compacted under pressure. (*C. A.*)

BOOK

19. Die Portlandzementfabrikation. CARL NASKE. 4th Ed. revised. Leipzig Th. Thomas. 469 pp. (*C. A.*)

Enamel

PATENTS

20. Method of enameling. EUGENE BERNINGHAUS. U. S. 1,452,635. The method of producing enameled chair sections which comprises applying an annular coating of fused enamel to the exterior of an annular sheet metal chair section having inwardly turned opposite edges by rotating said section with its exterior surface including portions of said inwardly turned edges in contact with a bath of fused enamel.

21. Enameling oven. D. LEISSLER. U. S. 1,447,795, Mar. 6. The oven is adapted for baking glazed articles. (*C. A.*)

Glass

22. Heat resisting glasses. W. E. S. TURNER. *Pottery Gaz.*, **48,** 607–17(1923).—The tendency of glass to fracture was at first attributed to lower thermal cond. of glass, so that, on heating it, the slow flow of heat across its walls resulted in great tension on the colder layers not exposed to source of heat. But relative cond. for heat alone does not entirely account for the fracture. The term "thermal endurance" was introduced by Winkelmann and Schott to denote the power of a glass to withstand thermal shock, and the formula which was deduced to represent the relationship of thermal endurance, F, to other properties was $F = \frac{T}{E\alpha}\sqrt{\frac{K}{Dc}}$ where T is the tensile strength; E, Young's modulus of elasticity; α, the linear coefficient of thermal expansion; K, the conductivity for heat; D, the density; and c, the sp. ht. It can be noted that the properties which directly affect the thermal endurance are tensile strength, elasticity, and the coeff. of expansion, the remaining three factors producing an effect proportionate either directly or inversely to their square roots. Hence attempts to improve heat resisting power of glasses have been either in the increasing of mechanical strength or of diminishing the coefficient of expansion. SCHOTT was successful in making glass articles of which the inner part had a lower coeff. of expansion than the outer, and when the glass cooled, the inside layer was in compression. This type fell under increase of mechanical strength. Coeff. of expansion of glass is intimately connected with its compn. and it has been found possible to make glasses having linear thermal expansions varying bet. 30 and 130 $\times$ 10^{-7}. Schott showed that different constituent oxides had *each* a definite effect on the total expansion of the glass and in conjunction with Winkelmann, so-called "expansion factors" were detd. The expansions were found to be additive and permitted of calculation from the formula $3\alpha = p_1a + p_2b$. p_1,p_2 being the respective percentages and a,b being the expansion factors for the constituent oxides. The following expansion factors were calculated by Winkelmann and Schott:

B_2O_3	0.1	Li_2O	2.0
MgO	0.1	BaO	3.0
SiO_2	0.8	PbO	3.0
ZnO	1.8	CaO	5.0
P_2O_5	2.0	Al_2O_3	5.0
As_2O_5	2.0	K_2O	8.5
		Na_2O	10.0

The expansion factors represent the contribution which each 1% of the particular oxide made to the total cubical expansion of the glass. It has been found that some of Winkelmann and Schott's factors need revision, the effect of magnesia, for example, not being as advantageous as the earlier factor. It will be seen from the table of expansion factors that two oxides in particular, namely, silica and boric oxide are associated with small expansion. The following analyses of 6 types of heat resisting glasses will illustrate the extent to which the 2 oxides have been used in modern times:

	Kavalier's combustion tubing	Austrian "Sun brand" lamp glass	Jena Thermometer 591	Jena "Best" lamp glass	British miners lamp glass	Pyrex glass
SiO_2	79.57	76.78	71.95	73.88	64.1	80.62
B_2O_3	...	...	12.00	16.48	22.0	11.90
As_2O_5	...	...	...	0.73	trace	0.66
Sb_2O_5	...	...	...	...	1.1	...
Al_2O_3	0.32	0.72	5.0	2.24	1.9	2.00
Fe_2O_3	0.04	trace	...	trace	..	0.14
CaO	7.80	6.52	...	trace	0.5	0.22
MgO	0.11	0.24	...	trace	0.1	0.29
PbO	...	...	...	...	0.6	...
Na_2O	0.66	11.14	11.0	6.67	9.7	3.83
K_2O	11.60	4.74	...	trace	..	0.61
Coefficient of linear exp. A	69.8×10^{-7}	83.0×10^{-7}	64.5×10^{-7}	46.7×10^{-7}	56.3×10^{-7}	$37.2\times10^{-}$
Coefficient of linear exp. B	.....	.....	57.0×10^{-7}	.....	.....	$32.0\times10^{-}$

A. Calculated by Winkelmann and Schott's expansion factors.

B. Experimental 0° to 100°C.

Linear expansion (thermal) of ordinary soda lime glass about 100×10^{-7}.
Linear expansion (thermal) of ordinary potash lead glass about 90×10^{-7}.

The modern glass contains boric oxide in very considerable amount. Pyrex glass, the most notable of glasses in recent years, contains roughly 80% of silica and 12% of boric oxide. There is a tendency in the manuf. both of chem. and heat resisting glassware, to make them strongly acid in character, since the acid oxides, silica and boric oxide are far superior to the basic oxides in giving low expansion. So far as the use of other oxides is concerned, the field is not exhausted. Thus, zirconia has a linear expansion coeff. of 8.4×10^{-7}, only little inferior to fused silica, but with a melting point of about 2600°C, clearly this oxide is first likely to find use, not in the pure, fused state, but as an addition to silica and the same is true of other refractory oxides such as titania and thoria. Some preliminary attempts have been made to produce glasses by adding small amts. of titania and zirconia to silica, the objects being to increase the resistance of the fused silica to devitrification and to attack by basic materials. The general results stated to be achieved are the production of a glass having superior mechanical properties and thermal properties to vitreosil, although actual numerical data have not been quoted. At Sheffield it has been found possible to add both zirconia and titania to the

ordinary glasses and it is hoped that the announcement of the results will soon be forthcoming. It may be noted, however, that when several per cent of titania is present, small crucibles of glass can be cooled down without special precautions to yield unbroken lumps. This indicates either a reduced thermal expansion or an increased mechanical strength: in any case an improved heat resisting glass. In the presence of reducing gases titania glass tends to be dark brown in color, although it is possible to retard such color development. Progress in the endeavor to increase the mechanical strength of glass might first profitably be made in a systematic detn. or redetn. of the relationship between the tensile, compression and other mechanical properties and the chem. compn. The Jena workers have already drawn certain conclusions as to the effect of different constituent oxides and additive relationships established, but in the author's view, their results need revision. As to the possibility of heat treatment, it is to be remembered that until devitrification sets in, glass contains no crystalline structure, the units of which could have their boundaries modified, as is possible in metals by cold working or by heat treatment. Owing to its brittleness, glass hardened by quenching possesses an element of risk, as when the outer layers are broken through, the mass is at once reduced to powder. J. W. H.

23. Coloring glasses with cobalt compounds. KITSUZO FUHA. *J. Jap. Cer. Assn.*, **364,** 587–95(1923).—Coloring action of cobalt compds. on various glasses has been studied. Formula of basal glass was $R_2O.RO.3SiO_2$,$R_2O.RO.O.5B_2O_3.3SiO_2$, $1.3R_2O.RO.6SiO_2$ or $R_2O.B_2O_3.6SiO_2$, in which R_2O is Na_2O or K_2O and RO represents CaO, MgO, ZnO, BaO or PbO. Results: (1) Color produced by CoO is stable and accordingly is alike for almost all kinds of glass except pink shade in soda glasses which can be distinguished from potash glasses only when amount of the oxide is small (2) no diff. in coloring power was observable between cobalt carbonate and cobalto-cobaltic oxide, Co_3O_4, obtained by igniting cobalt nitrate, if equivalent amounts were used (3) addn. of small amt. of alkali nitrate, potassium tartarate or arsenious acid to the batch had no influence on the coloring. Cf. *Ceram. Abs.*, **2** [3], 58(1923). S. KONDO

24. Temperature in pot furnaces. SANGORO TAKAHASHI (TOKIO ELECTRIC CO.). *J. Jap. Cer. Assn.*, **364,** 609–18(1923).—The author performed numerous expts. with two pot-furnaces having 10 or 16 covered pots and gives detailed descriptions or discussions on (1) calorific power of their coal (2) ht. required for melting their glass batch (3) compn. and calorific power of their producer gas (4) amt. of air required for the complete combustion of the producer gas (5) the theoretical combustion temp. (6) lowering of the temp. due to the heat absorption of the glass-batch and the conduction through furnace-walls (7) variation in the climate in Tokio (8) influence of climate on the draft of their stacks, (9) lowering of furnace-temp. due to wet coal, (10) measured temp. in their fur. and also (11) on the influence of season upon the cracking of glass pots. Heat utilized in melting batch was 8.6%, in a half-gas fired fur. "A" contg. 16300 kg.-pots, and 10.4%, in a Mond-gas fired fur. "B" contg. ten 250 kg.-pots, of that generated in each fur. by the combustion of the gases. Heat lost by conduction through fur. walls amounted to 15.9% in "A" and 19.0% in "B." The mean max. temp. observed close to pots was 1522°C in "A" and 1517° in "B." S. KONDO

25. Glass manufacture. ANON. *Raw Materials Rev.*, **2,** 154.—A part. of app. for molding glass is made from steel containing from 10 to 15% of chromium and from .5 to 5% of cobalt. Another suitable steel contains about 13% of chromium, about .5% of manganese, about .6% of cobalt and about .35% of carbon. Another steel contains chromium and about 4% of silicon. It is found that molds made from these steels have a longer life than molds made from cast iron, and that they are particularly suitable for use with a glass that requires to be worked at a high temp. O. P. R. O.

26. Glass forming machines. C. SAXTON. *Pottery Gaz.*, **48,** 629–34(1923).—A very complete description of the principles of various glass mfg. machines and the methods employed in the production of the various types of glass ware. J. W. H.

27. Feldspar for the glassmakers. F. C. FLINT. *Pottery Gaz.*, **48,** 670–71(1923).—See *Jour. Amer. Ceram. Soc.*, **6** [3], 413–6(1923). J. W. H.

28. Sanitary measures in milk industry safeguarded by constant watchfulness. Glass bottle and automatic machinery greatest factors; makes complete sterilization possible. ANON. *Glass Container*, **2** [7], 11, 12(1923).—Sterilization is observed by testing unfilled bottles many times a week in order to test the performance of each type of washing, rinsing and filling machine. Efforts to avoid contamination are practiced throughout the whole industry. W. M. C.

29. A study of the return and breakage problem of milk bottles. ANON. *Glass Container*, **2** [7], 1, 5, 6, 7, 46(1923).—Report of a survey by the Glass Container Association among the milk dealers in N. Y. City. It is estimated that 1,600,000 milk bottles are delivered in N. Y. each morning. The av. bottle makes 17 trips where formerly it made eleven. Improvement has come about as a result of checking up on delivery system and plant operations. Mechanical handling of milk bottles and the use of latest types of washing machines, conveyers, filling, sterilizing and capping machines have reduced breakage to less than 2%. Sterilizing is performed at 160°F, washing at 120°F, and rinsing at 100°F. Proper temp. regulation lessens breakage. W. M. C.

30. Fused quartz, silica glass or fused quartz. ELIHU THOMSON. *G. E. Rev.*, 68–74(1923).—Articles with illus. on the prepn., properties, and uses of quartz glass. W. M. C.

31. Abrasives and polishing powders for glass. J. W. FRENCH. *Trans. Faraday Soc.*, Oct.(1922).—The action of an abrasive is outlined briefly; rate of abrasion depends on size of grain, force of impact, number of impacts per unit time, and is propnl. to the load on the tool and also to relative speed of translation. Several typical abrasives are illustd. and their relative merits discussed, namely diamond splinters, carborundum, emery and rounded grains of sand. The action of polishing is discussed in detail. Polishing media, of which the best is ferric oxide or rouge, are referred to also. Innumerable scratches when a polished surface is etched is a series of minute percussion cracks which are quite invisible until the edges of the cracks have been opened by etching. The moment the etching vapor strikes the surface of the glass, the scratches flash instantly into view. Hitherto the assumption has been that a surface layer has been dissolved away, thus exhibiting underlying scratches. O. P. R. O.

32. The silvering of glass. ANON. *Optician*, **60,** 183(1920); *J. Soc. Glass Tech.*, **5,** 125.—Several methods are described. The first requires 4 solns. as follows: (1) 40 g. of crystd. $AgNO_3$ in one l. distd. water; (2) 6 g. of NH_4NO_2 in 100 g. of water; (3) 10 g. of KOH in 100 g. of water; (4) 25 g. of sugar in 250 g. of water; add 3 g. of tartaric acid, boil for ten min. and allow to cool, then add 50 cc. of alc. and dil. with water to 500 cc. All these solns. can be kept without undergoing alteration. Equal quantities of the 4 solns. are mixed and the glass is immersed in the mixt. with the side to be silvered facing downwards. The second method is a modification of Brashera's process. NH_3 is added to a 10% $AgNO_3$ soln. until the ppt. is re-dissolved; to the total vol. half as much of a soln. of KOH is added, and then more NH_3 until the mixt. is clear. A weak soln. of $AgNO_3$ is further added until a bright brown tint results. Silvering is carried out by using a mixt. of this and a sugar soln. contg. 10% of sugar, 10% of alc., and 0.5% of HNO_3. The side of the glass to be silvered should be on top. For another method, two solns. are used: (*a*) 8.5 g. of $AgNO_3$ in 200 g. of water; (*b*) 15 g. of Rochelle salt in 200 g. of water. NH_3 is added to the mixt. until the ppt. is almost re-dissolved and the soln.

filtered. Two solns. are also used in a fourth process: (1) sugar 20, HNO_3 4, alc. 175, water 1000 parts; (2) 15 cc. of a 1% $AgNO_3$ soln., 7.5 cc. of a 0.5% KOH soln., and 22 cc. of NH_3. NH_3 is added to the $AgNO_3$ soln. until the ppt. is re-dissolved then the KOH soln., and finally the rest of the NH_3. Soln. (1) improves with age; 170 cc. of it are added to soln. (2) as made. Looking-glasses can be silvered simply by employing a mixt. of a 1% $AgNO_3$ soln., which has been treated with NH_3 until the ppt. has nearly disappeared, and a 1% formalin soln. The surface to be silvered should be placed downwards. In all cases abs. cleanliness of the glass is essential and directions are given for ensuring this. H. G. (*C. A.*)

33. Notes on reheating of glass electrically. E. F. COLLINS. *Glass Ind.*, **3**, 223 (1922).—Glass is athermous to heat rays. At 100° 2.6 mm. of glass intercepts all heat radiations, and at 390° it intercepts all but 6%. The ratio of convected heat to radiated heat in the metallic resistor furnace varies from about 20% at 500°F to about 3% at 1600°F. Hence in the electric metallic resistor furnace the reheating of glass at temps. required for molding is secured almost entirely by radiant heat, and the temp. is under perfect control. J. B. P. (*C. A.*)

34. The heat balance of glass leers. G. GIANOLI. *Ind. laterizi ed aff.*, **1**, 16–8 (1922); *Chimie et industrie*, **9**, 115(1923).—G. counts on the following losses: producing steam required by the gas producer 3–3.2%; in gas producer (unburnt fuel in ashes, soot radiation) 1.2–15%; cooling of the gases in the ducts 4–4.1%; regenerating chambers 6.1–6.7%; conduction and radiation from the leer 43–44.9%; flue gases 19%. There remains but 12.5–13.7% for the fusion of the glass. A. P.-C. (*C. A.*)

35. Resistivity of vitreous materials. L. L. HOLLADAY. *J. Franklin Inst.*, **195**, 229–35(1923).—A study of the resistivity of hard, light flint, and lime glasses. J. S. H. (*C. A.*)

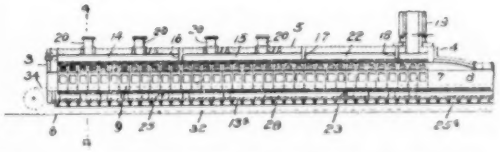
36. Opportunity for an American glass training school. WM. M. CLARK. *Glass Ind.*, **4**, 9(1923).—A discussion of the Glass Trade School in Zwiesel, Bavaria. Cf. *C. A.*, **5**, 1327. J. B. P. (*C. A.*)

PATENTS

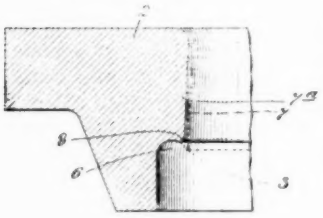
37. Apparatus for cutting sheet glass. CLIFFORD A. ROWLEY AND JOSEPH A. REECE. U. S. 1,453,856. In combination with a conveyor for carrying a sheet of glass longitudinally, an automatic apparatus for transversely cutting the glass sheet, comprising a cutting tool, a carrier for the tool, means for drawing the tool across the sheet, means for moving the carrier with the sheet while the cutter is operating, and means for returning the parts to the starting position.

38. Glass-cutting mechanism. ENOCH T. FERNGREN AND LEONARD D. SOUBIER. U. S. 1,453,315. The combination of a container for molten glass having an outlet orifice in the bottom thereof through which the glass issues, cutting mechanism comprising shear blades located beneath said orifice at opposite sides of the issuing glass, and means to advance said blades in spiral paths and thereby sever the issuing glass, said blades having V-shaped cutting edges, the outer portions of which overlap as the blades approach so that the cutting edges surround the issuing glass during the cutting operation.

39. Annealing furnace or leer. WALTER O. AMSLER. U. S. 1,453,116. In an annealing furnace or leer, an annealing chamber, a tunnel in communication with the annealing chamber, a chimney disposed between the annealing chamber and tunnel, and longitudinally extending heating flues disposed below the annealing chamber and extending beyond the chimney



and into the tunnel structure and exteriorly of the tunnel, said flues having connections with the chimney and arranged to produce a flow of gases from the tunnel back to the chimney. Cf. *Ceram. Abs.*, **2** [5], 96(1923).

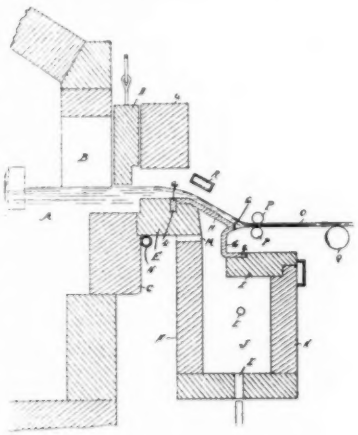


40. Method of manufacturing ring molds and the like. PETER KUCERA. U. S. 1,453,278. The method of manufacturing molds for pressed glassware which comprises producing a matrix of approximately the desired shape, then subjecting portions of the mold to compression forces to compact and harden the said portions, then finishing the hardened portions to the desired size and shape.

41. Apparatus for gathering and transferring molten glass. JOHN F. RULE. U. S. 1,453,285. Cf. *Ceram. Abs.*, **1** [11], 290(1922). The combination of a carrier rotatable continuously about a vertical axis, a gob forming receptacle carried thereby open at its lower end to receive a charge of glass, means to dip said receptacle into contact with a pool of molten glass during said rotation and gather a charge of glass by suction, a knife on said carrier, means to project the knife across the bottom of the receptacle to sever the gathered glass from the supply, a burner on said carrier, means to project the burner laterally to an operative position directly beneath the charge of glass and direct a heating flame vertically upward against the cut end of the glass, means to then withdraw the burner, and means to introduce the glass into a shaping mold.

42. Matrix device for molds. PETER KUCERA. U. S. 1,453,277. A block mold for the manufacture of glassware or the like comprising in combination a body portion provided with a mold recess, a mold table, a ring mold, a member mounted upon the side wall of the mold and being provided on one end with a configuration adapted to be impressed upon the article being molded and means operated by the ring mold to move said member into operative position and operated by the mold table to move said member out of engagement with the finished molded article.

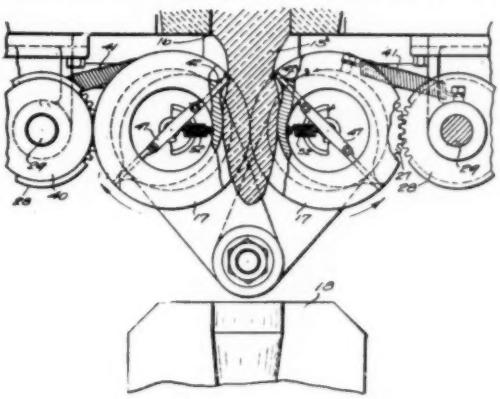
43. Apparatus for drawing sheet glass. WILLIAM J. JACOBS. U. S. 1,453,842. In a sheet glass drawing apparatus, the combination with a means for supplying molten glass continuously, of a metallic slab onto which the glass from the supply is adapted to flow in a continuous sheet, means for cooling the glass while on the slab, and means for stretching it from the edge of the slab into a sheet of predetermined thickness.



44. Method of and means for feeding molten glass. LEONARD D. SOUBIER. U. S. 1,453,290. The combination of a container for molten glass having an outlet at which a continuous supply of the glass is maintained and through which a column of glass is extruded, a pair of gob shaping rolls on opposite sides of the glass, means to rotate said rolls in contact with the extruded glass while the latter is still united with the glass in the container, and cutting mechanism arranged to advance with the shaping surfaces of the rolls and sever the glass into individual masses.

The combination of a gob forming roll having two oppositely disposed gob forming

recesses extending along its periphery, said roll having diametrically opposite slots between the ends of said recesses, cutter blades mounted to reciprocate radially in said slots, a yoke connecting said blades, means to rotate the roll, and a stationary cam arranged to shift said yoke in one direction when the roll reaches a predetermined point in its rotation to thereby project one cutter and to shift the yoke in a reverse direction when the roll has rotated a half revolution beyond said position, whereby each cutter is projected at the same rotative position. Cf. *Ceram. Abs.*, **2** [4], 74(1923).



45. Glass. E. C. SULLIVAN and W. C. TAYLOR. Can. 228,865, Feb. 20, 1923. A glass has a combined silica and alkali percentage compn. over 90 and a mol. ratio of alkali to silica between 26 and 29 to 100 and a mol. ratio of bivalent oxides to silica between 7 and 10 to 100. Cf. *Ceram. Abs.*, **2** [3], 64(1923). (*C. A.*)

46. Glass. W. C. TAYLOR. Can. 228,866, Feb. 20, 1923. A glass with a low sp. gr. contains at least 3% B_2O_3 and a sulfate salt. Cf. *Ceram. Abs.*, **2** [6], 126(1923). (*C. A.*)

47. Apparatus for bending continuous-sheet glass. J. P. CROWLEY and C. A. ROWLEY. U. S. 1,447,647, Mar. 6. Cf. *Ceram. Abs.*, **1** [12], 332(1922). (*C. A.*)

48. Leer conveyer for continuous-sheet glass. F. E. DEULIN. U. S. 1,447,648, Mar. 6. (*C. A.*)

49. Leer conveyer for continuous-sheet glass. H. S. DEPUTY. U. S. 1,447,649, Mar. 6. (*C. A.*)

50. Apparatus and method for drawing two sheets of glass in separable contact with each other. A. E. FOWLE. U. S. 1,447,654, Mar. 6. (*C. A.*)

51. Apparatus and method for flattening sheet glass. S. B. HENSHAW. U. S. 1,447,661, Mar. 6. (*C. A.*)

52. Drawing sheet glass. J. WHITTEMORE. U. S. 1,447,702, Mar. 6. Mech. features. (*C. A.*)

53. Muffle leer furnace adapted for annealing glass. C. L. SHARP. U. S. 1,447,633, Mar. 6. (*C. A.*)

54. Glass. GENERAL ELECTRIC CO. Brit. 188,451, Sept. 14, 1921. Transparent SiO_2 glass is made by fusing SiO_2 in a vacuum and then compressing the fused mass while plastic to reduce enclosed bubbles. A suitable construction is specified. (*C. A.*)

55. Glass. CORNING GLASS WORKS. Brit. 189,126, Nov. 14, 1922. A part of an app. for molding glass is made from steel contg. Cr 10–15 and Co 0.5–5%. Another suitable steel contains approx. Cr 13, Mn 0.5, Co 0.6, and C 0.35%. Another steel contains Cr and about 4% of Si. Molds made from these steels have a longer life than molds made from cast Fe, and they are particularly suitable for use with a glass that requires to be worked at a high temp. (*C. A.*)

56. Glass. TÔSAKU YOSHIOKA. Japan. 40,242, Oct. 6, 1921. When superheated steam is passed into a mixt. of silicates and NaCl heated below its m. p., the reaction

$2NaCl + SiO_2 + H_2O = Na_2SiO_3 + 2HCl$ takes place. The silicate is then melted with suitable materials for glass. *E. g.*, a mixt. of SiO_2 100, CaO 22 and NaCl 33 is heated at 700° in a rotating fur., into which superheated steam is then passed; a porous mass of silicate is smoothly produced. (*C. A.*)

Heavy Clay Products

57. Brick specifications. ANON. *Tonind. Ztg.*, **47,** 212(1923).—Building brick are burned brick made of loam, clay or clay like mass which may contain sand or grog. The test below shall be the average of at least 10 tests.

	Compression strength, kg./cm.²
Clinker brick	350
Hard burned brick	250
Common brick 1 grade	150
Common brick 2 grade	100

The brick should be 25 cm. long, 12 cm. wide and 6.5 cm. high. The per cent absorption should be less than 5% for clinker and less than 8% for hard burned brick. Clinker, hard burned brick and common brick used for building purposes should be sufficiently resistant to frost. In this test 10 bricks are saturated with water and frozen at −4°C 4 hrs. This is repeated 25 times. In the compression test none of the clinker brick shall have compression strength less than 300 kg./cm.² For hard burned brick none shall have a strength less than 200 kg./cm.² Common brick of 1st grade should have no brick having less than 120 kg./cm.² and those of the 2nd grade should have no brick having a greater strength than 90 kg./cm.² H. G. S.

58. The use of waste slate for brick making. G. HERMANT. *Rev. Mat. Constr. Trav. Pub.*, **162,** 60–2(1923).—Waste slate, ground to pass an 8 mm. screen, mixed with 5–8% slaked lime, and moistened with 8% water, was made into brick in a brick press. The brick were then hardened by exposing them for 8 hrs. to steam at 8 kgms. pressure. The crushing strength of the brick was 120 kgms. per sq. cm. Of a series of mixts., varying the size of particles, and the per cent of slaked lime used, the above mixt. gave the max. strength. The slate analyzed in %, SiO_2 57.2, Al_2O_3 26.0, CaO 3.30, MgO 3.00, ign. loss 3.10. L. N.

59. The treatment of calcareous clays. P. C. *Rev. Mat. Constr. Trav. Pub.*, **162,** 41B–43B(1923).—Review mainly of the work of BINNS, COATS, AND BLEININGER, and description of the Pratt machine for removing lime concretions from clay. L. N.

60. Equipment and methods used at Darlington Clay Products Co. (First Section.) C. FORREST TEFFT. *Brick and Clay Record,* **62,** 771–4(1923).—Description of brick machine, cutter, accounting for ware, drying, burning, fuel used, and fans. The plant is equipped with 8 round down-draft kilns with a total holding capacity of 580,000 brick. One of these kilns has just recently been built. The construction of this kiln is rather interesting as the kiln is carefully insulated throughout—in bottom, side walls and crown. The induced draft used in the kilns is furnished by two fans. One of these is located at the cold end or receiving end of the drier so that its suction draws the hot combustion gases from the kilns through brick flues and into cast-iron pipes located immediately underneath the drier tracks. The 2nd fan is located at the end of the main brick flue, which runs across the end of the drier and from which the first fan takes its hot gases for the drier. These two fans furnish the kilns with a constant, neverfailing draft *regardless of weather conditions.* The draft obtained is equivalent to a stack *300 ft. high heated all the time.* There is no difference with the draft system whether gas or coal for fuel is being used. The fan at the cold end of the drier is called the drier fan. It is a standard $5^1/_2'$ steel plate fan with $^3/_4$-steel housing, and is driven with a 20 h. p. motor

at 650 r. p. m. In reality only 18 h.p. is required to drive the fan. The temp. of the gases handled averages about 325°F and because of this the bearings on the fan are water cooled. The fact that the gases furnishing ht. for the driers are confined within pipes, is of course, positive protection against impurities coming in contact with the brick, as is the case with a waste heat drying system, where the gases from cooling kilns are traveling in the same chamber that contains the brick. This fact makes it necessary to bring in outside air into the drier to act as a carrying agent for the moist. coming from the brick. A steel housing fitted to the discharge end of the drier fan carries the hot gases to a 50 ft. stack immediately over the cold end of the drier. The stack being heated with these gases produces a suction or a draft at its base and, by means of opening dampers leading from the top of each tunnel an outlet is obtained for the moist. laden air from the brick. A 2nd fan called the kiln fan is located at the end of a large flue. The duty of this fan is to handle all the combustion gases that do not need to go through the drier. This is a number 12 multivane fan and actually requires between 15 and 20 h.p. to pull it. The fan runs at 450 r. p. m. and is equipped with water cooled bearings as the gases sometimes reach a temp. of 600°F. Plans are given of kiln bottom, drier and cross section of drier from end to end. This is to be supplemented by a 3rd section dealing with description of control equipment, method of setting, cooling, drawing, stocking, and details of the burners. J. W. H.

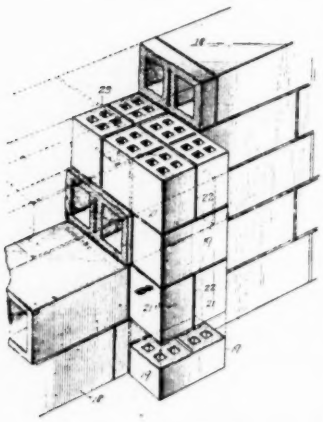
61. Equipment and methods used at Darlington Clay Products Co. C. FORREST TEFFT. *Brick and Clay Record*, **62,** 681–4(1923).—Description, accompanied by photos and sketch of operns. used in the manuf. of bricks at Darlington, Pa. plant of Fiske and Co., Inc. Detailed information is given relative to mine, clay drilling, blasting, drainage, ventilation, roof supports, supervision, haulage, handling of clay, clay storage, grinding, screening, ground clay storage, and mixing of clay with manganese. This article to be followed with another section devoted to drying and burning problems. J. W. H.

62. Manufacture of clay products in Germany. GUSTAV BENFEY. *Brick and Clay Record*, **62,** 602–3(1923).—One of a series of articles treating with the manuf. of clay products in Ger. Pick and shovel methods cannot be discarded in small pits where foreign materials such as lime, hard stones, etc., must be removed. Where such conditions do not exist a Liebscher dredger is used. This machine is of same general type as shale planer. Clay feeders of round and box type are used: the round feeder to feed material evenly while the box type feeder performs additional service of mixing clays with other ingredients. Sketches and photos of planer and feeders are given. J. W. H.

63. A new way to use the shale planer. ANON. *Brick and Clay Record*, **62,** 788–9 (1923).—A conveyor used in conjunction with shale planer permits working of face worthy of note. Photos and diagram are given. Advantages claimed are: (1) It keeps a smaller amt. of face open for wet and cold or exceedingly dry weather. (2) It increases the capacity of the machine over that which can be obtained with the same machine going straight into the bank for the tapering out from a full cut to no cut is almost instant on one end of the swing, while on the other it is the same as ordinarily experienced. This raises the efficiency of the Adel excavator working on a 25′ radius from 94% to slightly more than 96%. By this efficiency is meant that percentage of the cutting time at which the machine is cutting the full depth or full capacity. It should be clearly brought out that any machine which does not increase the radius of swing from one cut to the next will cut its full efficiency or capacity for one instant only and that is when the cut is directly ahead of the direction in which the machine is going. (3) The face of the bank which is left behind the planer and which in the ordinary plant will be cut over in about 60 d. is left circular so that it does not cave in or weather down easily. (4) The depth of the cut in the floor of the pit can be regulated so that

within two movements of the loading hopper, the machine can dig itself in easily 15 ft. if necessary. In starting in on a new cut this is sometimes quite an advantage. J. W. H.

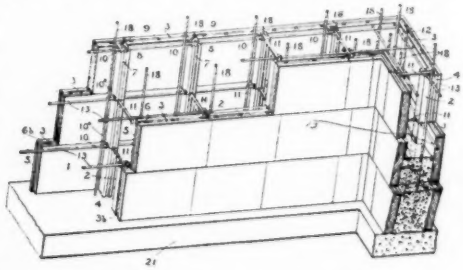
64. Automatic kiln firebox. STAFF ARTICLE. *Brick and Clay Record*, **62,** 614 (1923).—Description and sketch of system used by P. J. LAUBSCHER of Fredericksburg, O., used for feeding a small quantity of coal continuously. J. W. H.



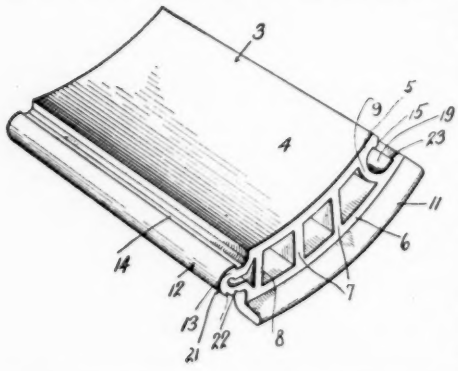
PATENTS

65. Pilaster construction. FREDERICK HEATH. U. S. 1,453,837. A pilaster construction, comprising wall blocks arranged in interbonding relation in superposed courses, the width of each pilaster block being slightly less than one-half its length, one of said courses including a pilaster block disposed parallel with and entirely outside of the wall face and the next superposed course including a pilaster block disposed at right angles to and overlapping said subjacent block and also overlapping a wall block within the wall body to securely bond the wall and pilaster together.

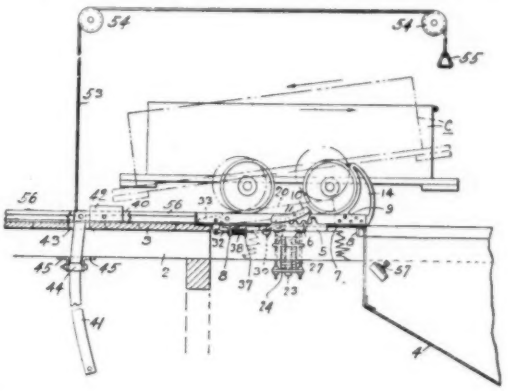
66. Masonry structure. WILLIAM F. WAGNER. U. S. 1,453,557. In a masonry structure, two series of blocks arranged apart so as to leave a space between them, the blocks of each series being provided with inner retaining supports and with sockets on their upper surfaces, in combination with aligning rods engaging the retaining supports and each spanning a number of said blocks, and transverse tie bars, each engaging the sockets of opposite blocks with its ends.



67. Building block. NELS A. NORD. U. S. 1,453,806. A building block comprising a body provided at one edge with a tongue portion which is curved along the plane of its axis beyond the adjacent edge face of the body, said tongue portion being provided at one side with a recess and at its opposite side with V-shaped grooves, the body of the block being provided at its opposite edge with a substantially U-shaped socket the mouth of which is of the same transverse breadth as the transverse breadth of the tongue portion at its base line, the intermediate portion of the socket being of greater transverse breadth than the intermediate and end portions of the tongue, the socket being of greater depth than the length of the tongue, the mouth portion of the socket being provided at one side with an inwardly disposed flange adapted to fit snugly in the recess upon the tongue of an adjacent block, the relative dimensions of the tongue portion and the socket being



such that when two of the blocks are placed edge to edge together the tongue portion of one block is completely received in the socket of the other block, with the face surfaces of the adjacent blocks in close contact with each other and sufficient space being left between one side of the tongue portion only and the adjacent surface of the socket to receive and completely enclose a filling of cement.



68. Kickback car dump. CHRISTIAN B. ANFINDSEN. U. S. 1,453,331. Cardumping apparatus of the kick-back type comprising a support, tracks carried by the said support, means for causing the said support to be tilted to cardumping position, auxiliary tracks also carried by the said support and means for resiliently maintaining the said auxiliary tracks inclined upwardly in the direction of movement of the cars coming upon the said support.

BOOK

69. Manual of Face Brick Construction. J. H. BLACK. Milwaukee, Wis.: C. N. Caspar. 116 pp. $9. (*C. A.*)

Refractories

70. On the thermal properties of refractories at high temperatures. YOSHIAKI TADOKORO. *Rept. of the Research Lab. of the Imperial Iron Works,* **2,** 41 pp.(1922).—*I. Refractory materials. II. Classification.* Raw materials, propns. and methods of mfg. various fire bricks at the brick plant of the Imp. Iron Works in Yawata are described. *III. Properties required in refractory materials* and their measurement at high temp. *IV. App. for measuring coeff. of exp. and its manipulation.* At one end of cylindrical test piece, 30 mm. in diam. and 180 mm. long, 4 small round holes, 5 mm. in diam., and 30, 80, 130 and 80 mm. deep, were bored symmetrically to its axis, and 3 quartz tubes and a thermo-element were inserted in them. The other end of the test piece was fixed by a quartz tube. It was heated in an elec. fur. with 2 platinum coils. Its expansion was calculated from the rotation of 3 mirrors attached to the ends of the quartz tubes. *V. Results of the expts.* (1) Linear change of raw silica brick in heating. (*A*) *First heating and cooling.* Exptg. with a dry raw silica brick, composed of 78.4% Tamba quartzite, 19.6% Usuki quartzite and 2.0% CaO, the following result was obtained: (*a*) The test piece expanded about 1.35%, when it was heated to 575° C. Then the expansion stopped abruptly owing to the transition of α quartz to β. (*b*) No change in length was observed up to 870° where a slight contraction, about 0.05%, corresponding to the transition of α tridymite to β_2, took place. (*c*) No remarkable change occurred between 870°–1130°; at the latter temp., sudden expansion occurred; it may owe to the acceleration of the transition of β quartz to β cristobalite at 1250° by the impurities. The expansion between 575° or 1130° and 1300°, amounting to 0.85% of original length, was irreversible. (*d*) Cooling curve shows no linear change between 1300–570°. It began to descend suddenly at 570°, leaving 0.98% expansion at ordinary temp. Besides, the heating and cooling curve shows some changes at 200–300°C.

(*B*) *Second heating and cooling.* The same test piece was heated once more to 1300° and cooled. The reversible parts of the curve were similar to the former. As for the irreversible change, it was slight and no permanent expansion was caused by the treatment. (*C*) *Third heating and cooling.* The inclination of the obtained curve was similar to that of the expt. *B*. (2) Heating and cooling curves of silica bricks. Burned bricks made of quartzite of Darien showed permissible permanent expansions only in 3rd or 4th heating to 1300°, while those made of red-and-white piebald quartzite, as used in the expt. 1, indicated no permanent expansion in the 1st treatment. (3) Irreversible expansion of a red quartzite. A red quartzite, contg. 94.26 SiO_2, 2.10 Al_2O_3, 1.40 Fe_2O_3 and 0.84 CaO, was heated at various temps. to find changes in wt. and permanent expansion. The result seems to comply with that of the expt. 1. (4) Coeff. of expansion of various bricks. The following table shows the coefficients of 5 kinds of bricks:

	Magnesia brick	Silica brick	Chrome brick	Grog brick	Red brick
Mean coeff. of expansion (20–1000°)	1.255×10^{-5}	1.142×10^{-5}	0.902×10^{-5}	0.760×10^{-5}	0.700×10^{-5}

Calculated expansions of a by-product coke oven and a blast fur., assuming their mean temp. as 1000°, agreed pretty well with facts. (5) Expansion curve of coal. Test piece made of 2 mm. grains of Futase coal and 10% water shrunk about 2.5% at 300–400°. (6) Expansion of slag brick and slag cement. 11 curves are given. (7) Expts. on Manchurian magnesites. Chem. compns. of the samples were as follows:

Color	SiO_2	Fe_2O_3	Al_2O_3	$CaCO_3$	$MgCO_3$
Blue	20.02	0.48	0.14	0.90	79.03
White	16.62	0.72	0.32	0.60	81.42

(*A*) *Dissociation at ordinary pressure.* The dissociation began at 400°, was most vigorous at 600° and was nearly completed at 800°. (*B*) *Irreversible changes in length, sp. gr. and wt.* Each test piece was a cylinder, 30 mm. in diam. and 30 mm. long, cut from one of the said ores, and was heated in an elec. carbon-resistance fur. for $^1/_2$, 1 or 2 hrs. at constant temp. White magnesite showed max. expansion of 0.6% at 600°, contracted to original length at 800° and shrunk 4% at 1400°. Blue sample expanded 0.2% at 600°, shrunk to original length at 800° and contracted 3% at 1300°. Abrupt contraction occurred at the last temp., indicating their incipient fusion at 1300° or 1400°C. The loss in wt. occurred almost entirely at 400–800°. Sp. gr. was 3.0 for 100–600°, 1.6 for 800–1400° (800–1300° for the blue magnesite) and 2.5 for 1400–1700°. (*C*) *Slaking test.* The results of slaking tests in atmosphere or boiling water indicated that the Manchurian magnesites must be burned at least to 1300° or 1400°. (*D*) *Expansion and contraction of magnesite at high temps.* The white magnesite expanded with temp. until 600° was reached where its expansion amounted to 1.4%. Beyond 600°, slight contraction began. It shrunk rapidly at 1100°C. The cooling curve is almost straight. *VI. Tech. position of refractories.* Short discussion is given on the subject. Cf. *Ceram. Abs.*, **1** [8], 208(1922). S. KONDO

71. A new commercial refractory. ANON. *Chem. Age* (London), **8**, 419.—Elec. sintered magnesite, a material having the highest m. p. of any commercial refractory is now being produced in quantity by the Carborundum Co., Niagara Falls, N. Y. It is made from carefully selected cal. magnesite and is thoroughly fused in an elec. fur. It contains about 95% MgO and less than 1% of iron oxide, and has a m. p. of about 2600°C. The material is especially resistant at high temp. to iron or iron oxide. This makes it most valuable for lining metallurgical fur., either in the form of bricks or in

granular form, tamped in. A further unusual feature of elec. sintered magnesite is that it does not contract when subjected to conditions encountered in industrial installations. O. P. R. O.

72. Refractory materials. H. DROUOT. *La Tech. Moderne,* **15,** Jan.-Mar.(1923).—Les Materiaux Refractaires gives a comprehensive summary of refractive materials, including a history of the refractory industry; procedure in fabrication of refractory materials; general properties of refractories; their analyses, chemistry, metallurgy and fusion point, compn. of crucibles for fusion of metals; diagrams showing the high temp. to which refractories may be subjected, which temp. is the detg. factor of their industrial application. The article is well illustd. with cuts and descriptions of machinery used in the refractory industry, including gyratory crusher, mixing, kneading, briquetting and molding machines. Much remains to be done in this industry with regard to the quality as well as the price of products, and a no. of problems have been but indifferently solved in the chem. and metallurgical industries. It is hoped that the engineer of tomorrow will have at his disposal, for high temp. work, materials of low cost, with high resistance and not easily affected by quick changes of temp., chemically neutral, not easily attacked by gas and dust in suspension, and which have a sufficiently high point of softening to allow performing other contemplated reactions. O. P. R. O.

73. Some properties of graphite. R. M. BURNS AND G. A. HULETT. *J. Am. Chem. Soc.,* **45,** 572–8(1923).—The ds. of various graphites were detd: by the liquid immersion method. The d. of pure graphite is about 2.20, and that of Acheson graphite about 2.30. The d. of C produced by the explosion of graphitic acid indicates that it is probably graphite. Completion of the "drift" or increase in wt. during immersion in the liquid was hastened by pressure, and the tendency to drift was largely destroyed by compression by the detn. of d. H. J. C. (*C. A.*)

74. Electric brass furnace practice. H. W. GILLETT AND E. L. MACK. Bur. Mines, *Bull.* **202,** 319 pp.(1922); cf. *C. A.,* **14,** 1784, 2133, 2753, 3195.—A report too comprehensive to permit abstracting. Numerous tables, illustrations, and both subject and name indexes are included. The purpose of the report is to present available information on what com. elec. brass furnaces are doing and can do, and to show, by description and exptl. test data, the evolution of present furnace types, including information on failures as well as on successes. Fundamental principles of design, construction, and operation are also considered. After a discussion of theoretical and practical advantages of elec. brass melting, of the distinction between steel-melting and brass-melting elec. furnaces, and the classification of elec. brass furnaces, the individual furnaces are considered under the following classes: (*a*) crucible furnaces, either lift-out or tilting; (*b*) hearth furnaces heated by a resistor, a smothered arc, a direct arc, or an indirect arc, the last two types in both stationary and moving furnaces, or by induction in a horizontal ring, a vertical ring, or a high frequency furnace. In conclusion are considered the factors governing the choice of a particular furnace, the relation of the central station, the cost of power, methods of testing furnaces, and the conservation possible in metals, crucibles, labor and health, and fuels. L. J. (*C. A.*)

75. Smelting silica bricks with reverberatory slags in a copper blast furnace. R. F. WOOD. *Eng. Mining J.-Press,* **115,** 404–7(1923).—Unusual changes were sometimes necessary during the World War. As a result Cu-impregnated SiO_2 brick and reverberatory slag, for instance, were both used. Either of these materials would be undesirable if used alone. It was found possible, however, by proper combinations to use them together. While there was a tendency toward formation of salamanders, even with unusual precautions, the practice was so developed as to get very satisfactory results, considering the unusual and difficult materials. W. discusses development of these changes in practice. H. C. P. (*C. A.*)

PATENTS

76. Ceramic ware and method of making the same. CHARLES W. SAXE. U. S. 1,454,000. A ceramic article consisting of an impervious portion of porcelain integrally united by vitrification with a porous portion of crystalline alumina granules bonded by vitreous clay material.

77. Process for making refractory products. LOUIS P. KRAUS, JR. U. S. 1,453,468. The method of treating refractory material consisting in roasting a ground mixture of the material and a combustible at such a clinkering temperature below its melting point as to produce a clinkered material in the form of spongy grains free from crystalline structure.

78. Graphite crucible. HIROSUKE NAKAMURA, KOZO NAKAMURA and HIKOSHIMA RUTSUBO KABUSHIKI KAISHA. Japan. 40,310, Oct. 18, 1921. The wall of the crucible forms V-shaped layers; it is manufd. by the machine described in 39,334. Owing to the special construction of the wall, it is resistant to changes of temp. and is very durable. (*C. A.*)

79. Brick. G. TUMURA. U. S. 1,446,238, Feb. 20. Crushed grains of liparite 1 and clay 3 parts are used together to form a brick which is light and fire-resistant. (*C. A.*)

BOOK

80. Manufacture and Uses of Abrasive Materials. ALFRED B. SEARLE. London: Pitman. 127 pp. 2s. 6d. (*C. A.*)

Whiteware

81. Comparative examination of the structure of Japanese and foreign porcelains. R. SHIGEMUNE. *Tokio Industrial Lab. Rept.*, **27** [6], 59 pp.(1922).—Microstructure of 33 Jap. and 24 foreign porcelains, mostly table wares, has been examined. *1. Porosity of the body.* The max. and min. sizes of pores in each section are given. There are 2 kinds of pores. One of them which seems to have been produced in forming, is large and has indefinite shape. It is frequently long and slender along the surface of the body. Sometimes it is developed at right angles to the surface with round sections. The other kind of pore which seems to have been produced by the evoln. of water-vapor and gases is round and usually small. *2. Size of grains.* The max. and min. sizes of quartz grains in each section are shown in a table. *3. Appearance of ingredients.* The state of melting of quartz grains is described for each thin section. *4. Formation of sillimanite, and translucency of body.* The translucency of body depends on the degree of mutual melting of raw materials, amount of ferric oxide, d. in black spots produced by massing of iron due to the melting of biotite and other ferruginous minerals, and formation of sillimanite. Descriptions on sillimanite, black spot and biotite are given for each thin section. The thin sections may be classified by the degree of sillimanite-formation in (*a*) sections showing no sillimanite, (*b*) those in which some of feldspar grains are replaced by masses of fibrous minute crystals, (*c*) sections whose feldspar has been sillimanitized almost entirely and (*d*) sections whose ground mass contains fibrous minute crystals. Black spots are usually round, measure mostly 0.001–0.2 mm. and are only opaque body in the thin sections. The result of burning a body for cone 9, composed of Katogun kaolin 35%, Hakuhoto quartz 23%, Omishima feldspar 35%, and Tokiguchi kaolin 7%, to cones 9, 12 and 15 indicates that black spots grow in size but diminish in number, as the burning temp. rises. *5. Jap. porcelains.* Jap. porcelains may be classified in 2 groups. (*a*) Porcelain made of plastic clay, feldspar and weathered granite. Thin sections are usually light brown and have sillimanite in their groundmass. (*b*) Porcelain mainly made of decomposed acid rock. Porcelain which has been

mainly made of weathered liparite has no sillimanite in ground mass, though its feldspar grains are rarely sillimanitized. It is generally fine-grained and is light gray or white. The microstructure of Kutani wares which are made of Hanasaka rock (weathered quartz-porphyry) 5–6, Gokokuji rock (weathered quartz-porphyry) 4–5 and Nabetani clay 3–6, resembles that of porcelain (*a*). *6. Comparison of Jap. and European porcelains.* (*1*) *Pores.* Pores in the European porcelains are generally less and smaller than those in Jap. wares. (*2*) *Size of quartz grains.* Generally speaking, quartz grains in the European wares are smaller than those in Jap. porcelains. (*3*) *Appearance of quartz grains.* Quartz grains in the European wares have classified outline, while only a few Jap. porcelains show similar structure. (*4*) *Formation of sillimanite.* The European porcelains are generally superior to the Jap. in this respect. (*5*) *Translucency.* Jap. porcelains are generally superior to European in translucency. 39 microphotographs are given. S. KONDO

82. Experiments on the manufacture of pure-white hard porcelain. MIKIYA AKATSUKA. *Rept. of the Pottery Lab.* (Kioto), **1**, 1–13(1922).—Many expts. were done with the purpose of producing pure-white porcelain with Korean kaolin as its chief raw material. The firing temp. was cone 14 all through the study. *1. Raw materials.* Korean kaolin of Daiyamen, Katogun, Keishonando, Gairome clay (highly plastic kaolin) of Tokiguchi, feldspar and quartz of Ehime prefecture, and talc of S. Manchuria were used. The Korean kaolin gave the following analyses: 45.06 silica, 38.44 alumina, 0.54 ferric oxide, 0.73 lime, 0.16 magnesia, 0.80 alkalies and 14.32 loss on ignition. *2. Compn. of body.* Its range was clay 54–67% (kaolin 33–53%, Gairome clay 6–21%), feldspar 21–29% and quartz 12–18%. These materials were used in air dry state. The content of moist. was as follows: kaolin 6.64%, Gairome clay 6.32%, feldspar 0.20%, quartz 0.08% and talc 0.08%. *3. Glaze formula.* Glazes tried were $\left.\begin{matrix}0.65\ K_2O\\0.35\ MgO\end{matrix}\right\}$ 75–0.90 Al_2O_3.9.5–10.0 SiO_2, $\left.\begin{matrix}0.70\ K_2O\\0.30\ MgO\end{matrix}\right\}$ 0.8–1.2 Al_2O_3.9.0–12.0 SiO_2, $\left.\begin{matrix}0.75\ K_2O\\0.25\ MgO\end{matrix}\right\}$ 1.0 Al_2O_3.9.0 SiO_2 and $\left.\begin{matrix}0.80\ K_2O\\0.20\ MgO\end{matrix}\right\}$ 0.85–0.95 Al_2O_3.8.5 SiO_2. They were composed of feldspar, Gairome clay, talc and quartz. *4. Bending and shrinkage of bodies.* Descriptions are given of the expts. *5. Forming.* The ease of forming by hand wheel, pull-down and jigger, and casting were tested. 0.3% sodium carbonate was added to the casting slips. *6. Glazing.* Glaze slips rich in feldspar are liable to settling. Therefore, a small amt. of acetic acid (about 20–30 cc. for 72 l. cask) was added. Its effect is not temporary as that of ammonium carbonate. *7. Results.* (*a*) The suitable grinding time for bodies was 25 hrs. with 100 kg. wet grinding cylinder. It was 35 hrs. for glaze when the same grinding cylinder was used. Talc has to be ground for 20 hrs. before it is used in glaze batches. (*b*) The following bodies were excellent with respect to forming, cracking in drying and burning color:

Korean kaolin	Tokiguchi Gairome	Ehime feldspar	Ehime quartz
33	21	28	18
38	17	28	17
44	19	23	14

(*c*) Glazes of the formulae, $\left.\begin{matrix}0.65\ K_2O\\0.35\ MgO\end{matrix}\right\}$ 0.90 Al_2O_3.10.0 SiO_2, $\left.\begin{matrix}0.70\ K_2O\\0.30\ MgO\end{matrix}\right\}$ 0.90 Al_2O_3.10.0 SiO_2, $\left.\begin{matrix}0.70\ K_2O\\0.30\ MgO\end{matrix}\right\}$ 1.20 Al_2O_3.11.0 SiO_2 and $\left.\begin{matrix}0.70\ K_2O\\0.30\ MgO\end{matrix}\right\}$ 1.20 Al_2O_3.12.0 SiO_2 were satisfactory. The last glaze which was most excellent among them was improved further in color and luster by partly replacing the Gairome clay with the kaolin. The batch was as follows: Ehime feldspar 41.4, Tokiguchi Gairome 8.0, Korean kaolin 5.7, Manchurian

talc 4.0 and Ehime quartz 40.8. (*d*) Most of 27.4 cm. plates shrank to 24.6 cm., of which 0.1 cm. owed to glaze layers, in drying and burning. S. KONDO

83. Study of translucent hard-faience glaze. JISUI UYEDA. *Rept. of the Pottery Lab.* (Kioto), **1,** 14–56(1922).—*I. Purpose of the study.* Usual transparent hard-faience glaze exposes all defects on body just as they are. Moreover, it has an excessive luster like that of inferior glazes. On the other hand, porcelain has a fine appearance, since it is constructed of translucent body, glaze which is not fully transparent and a translucent intermediate layer. The purpose of the study was to produce a hard faience with an appearance of porcelain by improving the said properties of the glaze and also by coloring its body and glaze. *II. Single opacifiers.* (*a*) *Cryolite.* It has a tendency of producing devitrified spots. Otherwise, the result was nice. (*b*) *Fluorspar.* It acted like cryolite. The use of an engobe composed of 49.5% fluorspar, 41.3% feldspar and 9.2% Gairome clay under a transparent glaze is promising, though the uniform application of the engobe was not successful. (*c*) *Stannic oxide.* It makes the glaze matt or gives an appearance like an enamel. (*d*) *Antimony oxide.* It behaves like stannic oxide. (*e*) *Zirconia.* It acts like stannic oxide, but produces bluish shade instead of yellow with the latter. (*f*) *Zinc oxide.* Its action as opacifier is very weak. However, it makes the glaze white and bright. *III. Compound opacifiers.* (*a*) *Stannic oxide and fluorides.* Satisfactory results were first obtained with glazes containing 3% stannic oxide and 5% fluorspar or cryolite. Starting with the results, effects of variation in the amt. of stannic oxide, fluorine, alumina and silica were studied. Among numerous batches, the following proved to be the best for cone 01a:

$$\left.\begin{matrix}0.32\ PbO\\0.10\ K_2O\\0.20\ Na_2O\\0.38\ CaO\end{matrix}\right\}\ 0.30\ Al_2O_3\ \left\{\begin{matrix}3.60\ SiO_2\\0.40\ B_2O_3\\0.15\ F_2\\0.063\ SnO_2\end{matrix}\right. \qquad (a)$$

The batch was composed of 49.40% frit, 10.17% white lead, 11.17% Korean kaolin, 1.74% Gairome clay and 27.52% quartz. The formula of frit is

$$\left.\begin{matrix}0.191\ PbO\\0.119\ K_2O\\0.238\ Na_2O\\0.452\ CaO\end{matrix}\right\}\ 0.119\ Al_2O_3\ \left\{\begin{matrix}1.380\ SiO_2\\0.476\ B_2O_3\\0.178\ F_2\\0.075\ SnO_2\end{matrix}\right.$$

0.0475 ferric oxide and 0.00380 cobalt oxide were added to 100 frit batch. (*b*) *Stannic oxide and zinc oxide.* Excellent result was obtained with a glaze:

$$\left.\begin{matrix}0.32\ PbO\\0.10\ K_2O\\0.20\ Na_2O\\0.38\ CaO\end{matrix}\right\}\ 0.30\ Al_2O_3\ \left\{\begin{matrix}3.60\ SiO_2\\0.40\ B_2O_3,\\0.12\ ZnO\\0.063\ SnO_2\end{matrix}\right.$$

composed of 50.0% frit, 10.1% white lead, 11.0% Korean kaolin, 1.7% Gairome clay of Tokiguchi and 27.2% quartz for cone 01a–02a. The formula of frit was

$$\left.\begin{matrix}0.190\ PbO\\0.119\ K_2O\\0.238\ Na_2O\\0.453\ CaO\end{matrix}\right\}\ 0.119\ Al_2O_3\ \left\{\begin{matrix}1.370\ SiO_2\\0.476\ B_2O_3\\0.143\ ZnO\\0.075\ SnO_2\end{matrix}\right.$$

0.0450 ferric oxide and 0.0045 cobalt oxide were added to 100 frit batch. (*c*) *Zirconia and fluorspar.* By introducing 0.07 ZrO_2 instead of 0.063 SnO_2 in the formula (1),

a good glaze was obtained. However, it was deficient in luster, although this was later improved by increasing the amt. of fluorspar. (*d*) *Antimony oxide and fluorspar.* Only a few expts. were done with these opacifiers, as antimony oxide is said to be poisonous. (*e*) *Bone-ash and fluorides.* Expts. with bone-ash and cryolite or fluorspar gave pretty good results, though the glazes were far inferior in translucency, luster and color to those with stannic oxide and fluorspar. *V. Coloring hard faience.* (*a*) *Coloring body.* The use of $CoSO_4.7H_2O$ or $Co(NO_3)_2.6H_2O$ is described. An example of nice bodies is: 60.0% of liparite of Amakusa, 18.0% Gairome clay of Tokiguchi, 17.0% amalgatolite of Mitsuishi, 5.0% feldspar and 0.058% cryst. cobalt nitrate (0.015% cobalt oxide). The batch was ground wet for several hrs. in a grinding cylinder. Then 0.0712% cryst. sodium carbonate was added and ground again. (*b*) *Coloring glaze.* The usual way of adding cobalt oxide to frit is not satisfactory, as it produces a blue with purplish gray shade. Therefore various mixts. were tried. Barium chromate gave greenish blue of porcelain glazes. For glazes contg. stannic oxide the use of a mixt. of cobalt oxide and ferric oxide in amts. of 0.0025–0.003% and 0.025–0.03%, respectively, in matured glazes is recommended. S. KONDO

PATENT

84. Sagger. ITSURO KASUGAI. Japan, 42,575 May 12, 1922. Holes are bored at the sides and bottom of a sagger with the purpose of saving fuel in the glost-firing of porcelain. S. KONDO

Equipment and Apparatus

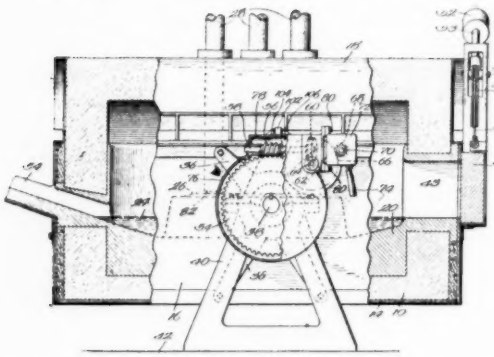
85. Compressibility of matter. Method and apparatus (patented) for measuring pressure exerted in a press. F. BONNET. *Rev. Mat. Constr. Trav. Pub.*, **162,** 58–60 (1923).—In compressing material, it is often necessary to know the pressure that is exerted in different parts of the press. For this purpose a modification of the Brinell method for hardness testing is applied. The device consists of a hard metal base plate, 5 cm. in diameter, that fits into a hollow hard metal cylinder. The base plate holds the metal sheath that is to register the pressure by indentation. The top of the hollowed cylinder is evenly bored out in three places, symmetrically located about its center, to keep in place 3 hard metal balls, each 1 cm. in diameter. These devices are then placed horizontally in different parts of the mass of material in the press, and then compressed. The pressure is evenly distributed over the surface of the device, the imprint on the metal sheath under each ball registering $^1/_3$ of the total pressure. The device is calibrated by plotting impression diameters against known pressures (*i. e.*, by weights). L. N.

86. Apparatus for photomicrography. G. DURANTE. *Compt. rend.*, **175,** 1201–3 (1922).—The app. described differs from the customary app. in that the source and microscope are hermetically sealed so that light cannot pass except through the ocular. A lamp with V-shaped filament gives a point source, all posterior rays being reflected by means of a spherical mirror. A rheostat affords adjustment for 3 different light intensities. Mirror, lamp, and condenser are enclosed in a jointed tube. The camera has the form and dimensions of a microscope case, through the top of which passes the ocular tube. The plate holder can be moved up or down on a rigid tube which is screwed on to the case but is demountable. The app. is readily portable, simple in operation, reasonable in cost, and has no bellows to limit size of exposure; by simple alignment of the plate, a strong magnification with feeble objectives is possible. With but small magnification, an image can be obtained at a distance of 2 m., which is bright enough to be seen readily by a limited audience. T. F. B. (*C. A.*)

87. New form of melting-point apparatus. H. A. BELL. *Ind. Eng. Chem.*, **15,** 375(1923).—A modification of the Thiele app. E. J. C. (*C. A.*)

PATENT

88. Electric furnace. ALFRED W. GREGG. U. S. 1,453,347. A metal receiving furnace box provided with doors through which material may be placed at one end, a pouring spout at the other end, means for leading electric current into the furnace to effect melting of material placed therein, trunions extending from opposite sides of the furnace, intermediate of said spout and said doors, journal supports for the trunions, an electric motor mechanism supported by a trunion for rocking the furnace on the trunions and expansion permitting means on the support preventing rotation of the motor about the trunion axis.



Kilns, Furnaces, Fuels and Combustion

89. Tunnel kilns. K. DÜMMLER. *Deutch. Topf. Zieg. Ztg.*, **54,** 95–6(1923).—Considerable power is required to force cars through a continuous kiln. This may be reduced by using a pitch of 1 to 20 or at least 1 to 10 thus allowing gravity to assist in forcing the cars through the kiln. The objections to this method is that the cars are slightly tilted. This may be overcome by using 2 sets of tracks, one inside of the other. The back wheels of the car rest on the outer track whereas the lower and the front wheels rest on the inner track which are elevated thus allowing the cars to pass through absolutely horizontal. H. G. SCHURECHT

90. Problems of continuous kiln burning. MARK A. TAYLOR. *Brick and Clay Record,* **62,** 597–8(1923).—Burning in the Youngren type kiln is explained. Kiln has 18 chambers, fired with fuel oil. Chambers are 32 ft. long, 16½′ wide and hold 40 to 50 T. drain tile or 70 to 80 T. of hollow ware. Ordinary firing period for a chamber is 36 hrs. with approx. 60 hrs. of preheating preceding. Attempt to obtain ½ to ¾-inch shrinkage per hr. completing it in 12 hrs. Chamber is held at a finishing temp. of 1950°F for 3 hrs. Stack gases are below 200°F; draft is of major importance. Drain tile kilns are ordinarily set at 16″ draft while closer settings are given 0.02 to 0.04 inches more. Pyrometers, cones, trial pieces, water smoking thermometer and draft gages are considered important. Opinions of others desired. See *Ceram. Abs.*, **1** [11], 276(1922). J. W. H.

91. Automatic feeding of fuel in Hoffmann continuous kilns. F. DELORME. *Rev. Mat. Constr. Trav. Pub.*, **162,** 43B–47B(1923).—Review of a detailed acct. of the results obtained with a "Colomb" automatic feeding device, reported in *Chaleur et Industrie,* Jan., 1923. L. N.

92. Mechanical burning of brick and tile. H. COUËTOUX. *Rev. Mat. Constr. Trav. Pub.*, **162,** 48B–54B(1923).—Descriptions and plans of the Hirt patented machinery. L. N.

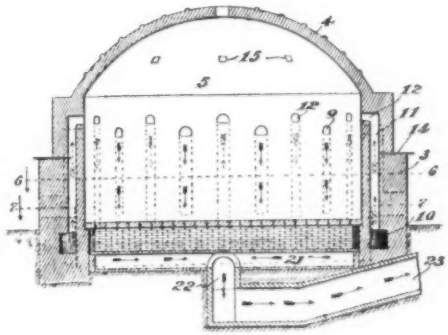
93. Methods of handling materials in the electric furnace and the best type of furnace to use. (Heat treatment.) F. W. BROOKS. *Trans. Am. Electrochem. Soc.*, **43** (Preprint).—A general discussion, with designs, of various types of elec. furnaces, such as, the plain box, the special box, the car, the recuperative and continuous types. Ad-

vantages and disadvantages of each and methods of handling the material to insure uniform temp. and high efficiencies are outlined. W. H. B. (*C. A.*)

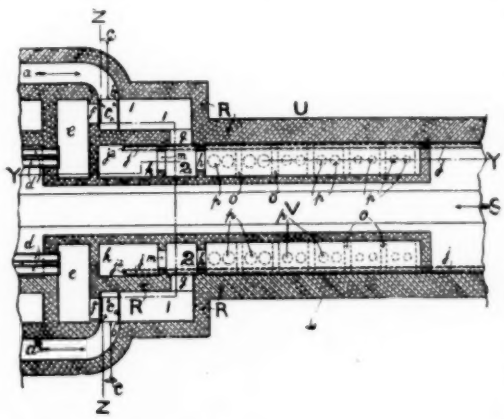
PATENTS

94. Improvement in kiln for burning brick and similar wares. TOKUSABURO SATO. Japan. 42,666, May 20, 1922. The kiln is provided with fire-boxes which have each a drop-arch and a channel-shaped wall at its rear. The drop-arch directs the flame produced on grate downward. The flame then strikes on the inverted-channel wall which is a kind of very low flash wall, situated much nearer to the grate than usual. The construction keeps the furnace-end hot and aids the complete combustion of gases. S. KONDO

95. Brick kiln. YASABURO SAITO. Japan. 42,989, June 30, 1922. This is a parallel ring kiln with 2 main flues between two burning channels instead of one as usual. Each main flue is connected with opposite burning channel by small flues which pass under the other. It has a drying chamber on the main flues. Another drying tunnel is constructed around the kiln. Pipes are imbedded in the kiln body over the crown. Hot air produced in them by conduction is utilized in drying bricks by connecting the pipes with the drying chamber and tunnel. S. KONDO

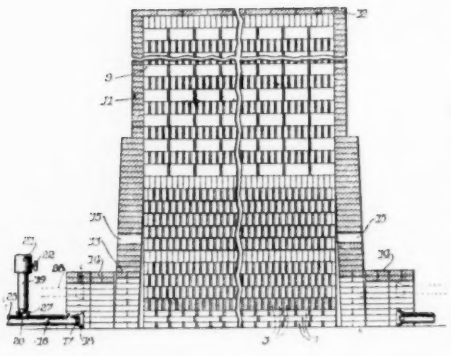


96. Kiln. ROBERT J. DYER. U. S. 1,452,638. A cylindrical kiln comprising a main wall having a smooth inner surface, a dome supported thereby, said main wall provided interiorly with a plurality of vertical flues each communicating at its upper end with the interior of the kiln, said wall being formed interiorly of its base with an annular duct with which the lower ends of alternate flues connect, said wall being further provided interiorly with a plurality of firepots opening at the exterior of the wall and one associated with alternate flues, and an outlet beneath said kiln connecting with said duct.



97. Gas-fired oven or kiln. JOHN HENRY MARLOW. U. S. 1,452,887. A tunnel oven or kiln provided on opposite sides with combustion chambers and air supply pipes, passages communicating with the combustion chambers, said passages decreasing in area towards the front of the oven or kiln, and a series of orifices which communicate with said passages. Cf. *Ceram. Abs.*, **1** [12], 301 (1922).

98. Method of and means for burning bricks. GRAFTON E. LUCE. U. S. 1,453,850. In a kiln, a stack of green bricks and a foundation of burned bricks, said foundation



of burned bricks having a furnace therein and said stack of green bricks having a furnace therein adjacent the furnace in the foundation, said furnaces being connected at intervals through a foraminous wall of burned bricks.

99. Gas producer. R. DAAE. U. S. 1,445,300, Feb. 13. The pat. relates to a mechanism for supplying fuel to a producer through a feed opening in the cover. (*C. A.*)

100. Pure cresol from crude tar acids. I. H. DERBY and W. HIGBURG. U. S. 1,445,668, Feb. 20. Crude-tar acids are treated with a small fraction of the chem. equiv. amt. of caustic alkali and after reaction the material is cooled, C_6H_6 or toluene is added and the material is extd. with H_2O_2 to sep. the alkali metal compds. (*C. A.*)

101. Removable-top continuous kiln. T. B. MOATS. U. S. 1,447,682, Mar. 6. (*C. A.*)

Geology

102. Bauxite. ANON. *Keram. Rund.*, **31,** 105(1923); *Mines, Cavueres, Grandes Entrepries*, **3,** Jan., 1923.—Bauxites are partly products of disintegration of feldspar rocks, such as granite syenite and gneiss. U. S. is the principal source of bauxite, 90% of the U. S. bauxite comes from the Saline district of Arkansas. Here there is a 3.3 m. strata of bauxite which was derived from syenite. The next important source in U. S. is that in Ga. in Andersonville of the Sumter district. Bauxite found in Ga., Ala., and Tenn. are usually mixed with white clays. The U. S. bauxites have 15 to 33% combined H_2O and varying amts., of hygro. H_2O. In Ark. the freshly mined bauxite is passed through a rotary kiln in which it is heated to 600°C, thus reducing the hygro. H_2O to $^1/_2$ to 1%. The bauxite which is used for abrasives, and refractories is calcined in a rotary kiln so that it contains less than 1% combined H_2O. In 1919, 272,270 T. were used for Al, 67,842 T. for chem. purposes, 35,395 T. for abrasives and 1,074 T. for refractories. Bauxites of good quality also come from Brit. Guiana in S. Amer. In France a red variety is obtained in Herault and Bonche-du-Rhöne. The following data show the production of bauxite in different countries.

	1913	1917	1919	1920
U. S.	210,241	568,690	376,566	521, 308
France	304,323	118,973	160,820	186, 693
Dalmation-Istria	...	160,501	...	...
Italy	6,840	7,664	2,924	37, 360
Brit. Guiana	...	2,037	1,976	29, 390
England	6,055	14,724	9,221	...
India	1,184	1,363	1,682	...
Spain	...	...	1,751	...

The bauxite for Al must contain at least 52% Al_2O_3 and not more than 4% Si and 6.5% Fe_2O_3; for alum $Al_2(SO_3)_3$ the bauxite should contain at least 52% Al_2O_3 with a low content of Fe_2O_3 and TiO_2; for the production of refractories, it should contain a low content of Fe_2O_3. A new use for bauxite has been found in the production of a new cement. A mixt. of bauxite, coke and $CaCO_3$ is molten together. After cooling, the cement

is ground fine. This cement contains 50% CaO, 40% Al_2O_3 and 10% SiO_2. It is a very rapid setting cement and becomes harder after setting 24 hrs. than Port. cement after 28 days. It is resistant to sea waters. H. G. SCHURECHT

103. China clay (Cornwall, England). ANON. *Chem. Age*, **8**, 15(1923).—A fresh bed of fine china clay has been located at Cornwall: expts. have shown that it reaches to a depth of 60 ft.; and it is anticipated that there is an area of at least 20 A. O. P. R. O.

104. Sweden-stone quarries. ANON. *Swedish Yearbook*, p.129(1922).—The quarrying of various kinds of stone is of great industrial importance to Sweden; granite, marble, slate, sandstone, quartz, feldspar, and pot-stone are quarried. O. P. R. O.

105. Phosphates in Morocco. ANON. *Oil & Colour Trades Jour.*, **63**, 652(1923).—By the discovery of rich and vast phosphate beds, Morocco has become a potential factor of economic importance. These extensive beds of fine sand are phosphate of lime of a percentage varying from 68 to 78%. Estimates of their quantity vary from "many millions of tons," to "hundreds of millions." O. P. R. O.

106. Glass-making sands (Western Australia.) P. G. H. BOSWELL. *Chem. Eng. and Mining Rev.*, **15**, 199(1923).—Glass-making sands obtained in the neighborhood of Lake Gnangara, W. A., are said to be of very high quality. B. states these sands are highly suitable for white flint glass, the best bottles, pressed ware, lighting glass, chem. app. and table ware. O. P. R. O.

107. China clay. Its composition, preparation and uses. H. F. COLLINS. *Chemistry & Industry*, **42**, 88–91, 114–7(1923).—A description of the compn., distribution, methods of working, purification, uses and economic importance of china clay. C. C. D. (*C. A.*)

Chemistry and Physics

108. Calculating heat losses in furnaces. O. I. HANSEN. *Blast Furnace & Steel Plant*, **10**, 437–40(1922); **11**, 117–22(1923).—The heat losses in boilers due to incomplete combustion of the fuel cannot be detd. with exactness with the ordinary Orsat app. H.'s method is to absorb the CO_2 in KOH and burn any H_2, CH_4 and CO present by heating the gas in a Pt capillary tube and observing the contraction. From this the percentages of combustible gases and the heat loss may be calcd. by suitable formulas. The analysis is carried out over Hg, and errors due to temp. change in the measuring buret are cut down by air cooling the water-jacketed buret and by using a compensating U-tube pressure equalizer. The method is claimed to be much superior to the ordinary Orsat method or to slow combustion or explosion methods. C. H. H., JR. (*C. A.*)

109. The rapid determination of potash in acid-insoluble silicates. Addendum. M. M. GREEN. *Ind. Eng. Chem.*, **15**, 429(1923).—Additional references are given. See *C. A.*, **17**, 501. H. G. (*C. A.*)

BOOK

110. Die physikalischtechnische Untersuchung keramischer Kaoline. JOHANNES STARK. Leipzig: J. A. Barth. 145 pp. M160. (*C. A.*)

General

111. Clay products output. ANON. *Brick and Clay Record*, **62**, 689–90(1923).—Detailed statistics of clay products output for years 1921, 1919, and 1914. J. W. H.

112. Symposiums: Casting of clay wares and oil firing of kilns. ANON. *Clay-Worker*, **79**, 462–3(1923).—Abstracts of papers read at annual meeting of N. J. Clay workers Assn. and the Eastern Section of AMERICAN CERAMIC SOCIETY, New Brunswick, N. J., December, 1922. J. W. H.

113. Ceramic Industries—Sweden. ANON. *Swedish Yearbook*, p.130(1922).—Brick, china, glass, cement and lime industries are the most important mineral industries in Sweden. O. P. R. O.

114. Air humidity and drying. P. H. PARR. *Intern. Sugar J.*, **25**, 16–20(1923).—Tables give for dry air the vol. and total heat per lb. and for satd. air the vapor wt., vol., total heat and heat increase per degree F from 40° to 100°. By the use of these tables the amt. of heat required to dry a given wt. of sugar to any given moisture content can readily be ascertained. W. L. O. (*C. A.*)

PATENTS

115. China clay. N. TESTRUP. U. S. 1,446,949, Feb. 27. Wet china clay contg. a large amt. of liquid is freed from superfluous liquid until a layer is obtained of small av. liquid content, varying through the layer, and clay is removed from the denser portion of the layer and fed as a film on to a drying surface heated by compressed vapor to a temp. only slightly in excess of that necessary to evap. the moisture in the clay. (*C. A.*)

116. Coating ceramic ware. METALLISATOR GES. Brit. 189,085, May 24, 1922. Ceramic cooking vessels are coated with Al or Fe. The vessels are heated to a temp. of 300–400° and the metal is applied by any of the known metal dusting processes. (*C. A.*)

117. Process of making vulcanization accelerators. PAUL I. MURRILL. U. S. 1,453,515. The process of making an oxidization product of a metallic salt of an organic acid, which comprises, condensing dimethylamine with carbon bisulfide, precipitating with an aqueous solution of zinc sulphate to form an insoluble zinc salt, and then oxidizing the precipitate.

BOOK

118. Water glass. A bibliography. MORRIS SCHRERO. Pittsburgh, Pa.: Carnegie Library. 83 pp. (*C. A.*)

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BULLETIN

of the

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical and Scientific Questions and Promotion of Coöperative Research

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Vol. 2 July, 1923 No. 7

EDITORIALS

EDUCATIONAL TRAINING IN CERAMIC SCIENCE

Science is a general term covering both the fundamental and the applied knowledge of things and processes.

Collegiate education is a systematic training in the finding and marshalling of proven facts and theories in the solution of problems.

The acquiring of an education, the knowing how to find and use knowledge is a gift possessed by men in varying degrees. The simple minded or deficient person, cannot acquire much of an education; he has very little capacity for finding and using knowledge. To some, an education comes naturally; they observe and search for whatever knowledge pertains to the things in which they are interested. To others, education is not so natural. Ability to paint, sing, orate, spell or to be a mechanician, electrician or builder is a talent. Education is a talent which is developed by some people more easily and to a larger degree.

There is no artist, musician or mechanic who attains proficiency by any method other than systematic, diligent practice. Those who have the guidance of trained teachers acquire proficiency in their talents much more quickly, and their special talent is more broadly and thoroughly developed.

The retention of an acquired proficiency in a given talent also requires constant practice. Practice not only makes more perfect, but is abso-

lutely essential to sustained ability, whether it be as an artist, artisan or scientist.

There are specialists of many kinds in music, painting, crafts and writing. Talents of all sorts find their best development and expression in some special way or line. An inventor of electrical things would not, as a rule, have skill or ability to invent in other lines. A first class architect would, as a rule, do poorly as a sculptor, and a pianist would not do equally as well as a violinist. A few exceptional people have more than one talent highly developed, but these are the exceptions.

So it is in education. It would be idle for one to attempt acquisition of ability to find and apply knowledge in any other than the line in which he has a special talent. Bankers, merchants, preachers and lawyers are such by choice, but their choice was dictated in most cases by natural ability to serve in the vocation chosen.

Ceramic industries need specialists. They require the services of artists, salesmen, scientists, electricians, managers of men and financiers. Manufacturers of brick require the services of some artisans having talents and education in lines not required by the table ware manufacturers. The technical tasks for which graduates of ceramic schools are employed differ sufficiently in brick and pottery to require a different sort of view point and adaptability. The brick industry is more in need of a constructive engineer, and the pottery of a physical chemist, yet the technical man for each of these industries could well be prepared by the same sort of educational training. They could with profit have searched the same portion of the world's accumulation of knowledge (recorded facts) and could have had the same practice in analyzing and applying this knowledge to definite problems. These two men, each having had the same sort of educational training, will still possess a natural difference in adaptability to do industrial work because of their differences in points of view, interest and talents.

Since the view-points, interest and talents in the field of industrial ceramics are not developed in the young school fellow until after he has made a partial survey of the field it may be difficult to say what difference in preparatory training each should have for ceramic service. Rather than an instructor passing judgment on the pupil's adaptability, and rather than leaving it to the lad's blind choice as to what special training he should have, it may be better to give all the same course of rigid and thorough training in the searching and analyzing of knowledge for the solution of arbitrarily chosen practice problems.

The writer of this editorial does not believe in the one course of training for all, and yet he realizes the practical limits in variation of courses of training which any one school can offer. Elective or optional courses are not practical, for these do not give opportunity for the most beneficial

systematic development of the youth's educational possibilities; it risks too much to his unintelligent choice and whims, dictated as these are by social and other ambitions outside of his educational training in ceramics.

It did seem practical to the writer when he outlined the first courses in ceramic training at the University of Illinois to have two distinct courses—one engineering and the other science. The judgment then used was reversed by those who later had charge, but affirmed still later when others again instituted the two courses.

The problems of fabricating and burning are, to a large extent, the same in all clay working. If one can succeed as an engineer in a brick plant he ought to succeed equally well in a pottery as far as the engineering problems of flow of ware through the factory are concerned. One of the most original and successful china ware superintendents in this country spent several years making, installing and operating brick machinery prior to taking a short industrial course in ceramics at a college.

The glass and enamel industries wish their ceramists to deal with chemical and physical problems in the uniform production of high quality glass having certain properties, and to devise the furnace and its control in which the glass or enamel is produced.

In pottery, wall tile, floor tile and terra cotta there are similar physical and chemical problems in mixtures and colors and in the use of these in meeting trade demands. It requires more than mere maintenance of quality, reproduction of samples and technical control of plant operations. To serve in those ceramic industries where new effects, color combinations and new products are the essentials to continuing in business the ceramic chemist must be ever awake to development and promotion of new things. He must also either possess a constructional imagination and an artistic conception, or he must be closely allied and in close sympathy with men who possess these creative talents. The ceramic chemist must be more than a compounder of glazes, colors and bodies. He must conceive and know how to execute, as well as to provide the materials and mixtures.

The terra cotta industries are in need of ceramic chemists who can go along with architects in the conceiving of architectural effects. It is the task of the ceramic chemist who serves most fully in terra cotta to execute with the modeler and sculptor the conceptions of the architect and to be able to appreciate, understand and interpret the dreams of architectural artists.

The present day manufacturing conditions make it profitable, if not necessary, to be ready to diversify factory products. The wall tile and sanitary ware factories are now making bath-room fixtures in china. From the producing of these to the making of similar products for widely different purposes is natural. The grinding wheel factories are now producing refractory articles and non-slip tile. It pays ofttimes, from

an operating standpoint, to have a diversity of product. The necessity for a variety in art pottery is more generally understood but the same holds true in architectural tile and in decorative table ware.

No matter how well the ceramic chemist may be trained in the production of bodies, glazes and colors, and in the technical control of processes, he will be a failure and destined to assignment to routine tasks unless he is creative and unless he keeps abreast with the market possibilities. This requires that his interests, studies and activities shall extend beyond the laboratory, clay shop and kiln house. It requires that the ceramic chemist shall commune in person and through the literature and organized associations with those whose creative imaginations include the use of things which his factory can produce. It requires that he shall ever be familiar with all methods and processes for producing ceramic wares. He must know and have evaluating appreciation of both the fundamental and applied science researches that create information on ceramic materials, mixtures and processes.

There comes no time in one's active practice as a ceramic technologist when he can afford to cease searching the world's literature and communing with fellow ceramists. There comes no time when he can fail to know the best method of analyzing problems, and the source and use of materials. His educational training cannot be allowed a let-up. He must continue systematic searching by methods of his own devising.

One's fund of knowledge, cannot be greatly increased. While learning new facts, old ones are being forgotten. This is why the progressive and successful ceramist has his own card index of recorded knowledge, and why he values so highly the abstracting of the world's ceramic literature which appears in this *Journal* each month.

No matter what collegiate training and talent one may have had in the use of knowledge, he will make good only by keeping in contact with his fellows and by extending his activities beyond the factory and laboratory routine to the creative and promotional. One must have both the *incentive* and the *ability* to create; and this incentive does not often come to a recluse.

The educational training essential to the fullest success as a ceramic technologist is beyond the possibilities of college lecture halls and laboratories and can be acquired only by individual effort in collaboration with fellow ceramists and users of ceramic products. He who considers his course of training finished should be ready to retire by choice, for retire he will. It is that he may continue and broaden his educational training that the AMERICAN CERAMIC SOCIETY was founded and is continuing.

The success in service as a ceramist is more dependent upon the educational habits and system which one continues while employed than upon educational training received in school. This is made very evident by

many ceramists of ability, who either have had no special scholastic training or, at the best, have had only a brief collegiate course.

Collegiate training is of value, but of more value is the continued searching and applying of knowledge and the seeking of inspirations and opportunities outside of and beyond the limits of the routine tasks.

Two of the most effective ceramic educational institutions are the collegiate ceramic departments and the AMERICAN CERAMIC SOCIETY. There are other educational helps, but we submit that, given the self-insistence to improve one's education, the next in importance is participation in the affairs of the AMERICAN CERAMIC SOCIETY and that it is profitable for an employing concern to insist that its technical men and plant operators do so participate.

MESSAGE FROM PRESIDENT GREAVES-WALKER

During the month of June each of the ceramic schools sent out into the industry a number of young men who expect to make ceramics their life work. Most of these young men are now or will become members of the SOCIETY. To them let us, who have passed "through the fire," extend the hand of fellowship.

The SOCIETY, formed by a few enthusiastic technical men, has assumed the rôle of a "Big Brother" to the young technical men entering the industry. The first six months or a year often makes or breaks them in, so far as their career is concerned, and a helping hand, patience, and good advice will in most cases carry them over the rough ground onto the straight road of success.

To the graduates we extend the hand of welcome to our ranks with the hope that they attempt to give to the SOCIETY more, if possible, than they receive from it.

A new ceramic school looms on the horizon. The clayworkers of Georgia have determined to locate such a school at the Georgia School of Technology, better known as "Georgia Tech." Their efforts and determination are the more commendable in that they have decided that whether the State Legislature comes to their assistance or not they will themselves contribute sufficient funds to erect the necessary buildings and kilns out of their own pockets. The interest shown can be gaged by the fact that the *Atlanta Constitution*, one of the leading newspapers of the South, has offered to contribute $8000 to cover the operating expenses for the first year.

The AMERICAN CERAMIC SOCIETY congratulates the clayworkers of Georgia and the South and wishes them every success in this laudable undertaking.

May we again call the attention of the members to the Summer Meeting? Can we not have a record breaking attendance on the splendid trip on the Great Lakes? Make up your mind now to attend with your family, August 8, 9, 10 and 11.

Several very successful Section meetings have been held during the past two months. No better indication that the SOCIETY is alive can be found. The officers realize how much work on the part of a few men is required to make these meetings successful. We congratulate these men and bespeak for them the support of the Section members.

The idea adopted by several of the Sections of holding joint meetings with branches of other engineering or technical societies has proven very successful and is recommended to those Sections which have not as yet tried it.

PAPERS AND DISCUSSIONS

THE COLLEGE ART ASSOCIATION OF AMERICA

By Edwin M. Blake

ABSTRACT

The College Art Association, whose members are principally teachers of art in American Colleges, holds annual meetings for the reading and discussion of papers on the teaching of art, its history, and the principles of design. The twelfth annual meeting was held at the Museum of Fine Arts in Boston and at the Fogg Art Museum of Harvard University, April 6, 7, 1923. The Association publishes *The Art Bulletin*, issued quarterly, in which appear many of the papers presented at its meetings, beside other papers and reviews of books. References to some of the more important articles, including one on "Antique Glass," are given.

Were one asked to mention a few of the most important societies of national extent which minister to art education, he might well answer: The American Federation of Arts, The Eastern and Western Arts Associations, and The College Art Association of America. The American Federation through its large individual membership and by serving as a bond of union between the majority of the leading art societies of the country is able to make its influence cover a wide range. Its particular sphere of activity has been to extend the understanding and appreciation of art by the general public. To this end it publishes the *American Magazine of Art*, holds annual conventions, and circulates lectures and exhibitions. The Eastern and Western Arts Associations, whose large memberships consist of teachers of art and manual training in the grammar and high schools, are especially concerned with methods of teaching in those schools and the awakening of art interest in the younger students. The College Art Association has necessarily a smaller number of members who are principally teachers of art in the colleges, universities, and higher technical schools of the United States, and its interests chiefly fall under three headings: methods of instruction and contents of courses in art for the higher institutions of learning; history of art; and the technique and principles of design. The object of the present paper is to briefly describe those activities of the College Art Association which would seem to be of interest to the members of the Art Division of the American Ceramic Society.

It is the custom of the College Art Association to hold annual meetings at about Easter time, lasting two or three days, at which papers are read and discussed, local art collections visited, and social functions enjoyed. The twelfth annual meeting was held at the Museum of Fine Arts in Boston and at the Fogg Art Museum of Harvard University, April sixth and seventh, 1923. Other places of meeting during recent years have been New York, Cleveland, Washington, and Philadelphia. The Association publishes, *The Art Bulletin*, of which the first four numbers appeared annually, but beginning September, 1919 it has been issued quarterly.

Beginning with Volume V, September, 1922, the size has been increased from octavo to quarto permitting larger illustrations of objects of art. One of the undertakings of general interest carried through by the College Art Association is the publication of a list of "Books for the College Art Library" (*Art Bulletin*, Vol. III, 1920, pp. 3–60), a comprehensive bibliography of the fine and decorative arts, the result of several years' work by the committee in charge.

Under the heading "Art Education" may be mentioned the discussion on "What kind of technical art shall be taught to the A.B. student?" which took place at the sixth annual meeting at Cincinnati in 1917, and papers by Prof. Pope of Harvard University and Miss Kallen of the Boston Museum of Fine Arts on "The Teaching of Drawing and Design in the Secondary Schools" (*Bulletin* No. 3, 1917). In the fourth number of the *Bulletin* (1918) is a paper by the late Prof. Arthur W. Dow of Columbia University, "A Course in Fine Arts for Candidates for the Higher Degrees," and one on "Technical and General Education in the Arts" by Director E. R. Bossange of the Carnegie Institute. Other papers of note are "Schools, Colleges, and the Industrial Arts," by Richard F. Bach of the Metropolitan Museum of Art (*Bulletin*, Vol. II, 1920, pp. 171–175); and "A National Program of Industrial Art Education" by Charles A. Bennett (*Bulletin*, Vol. III, 1920, pp. 84–91). At the twelfth annual meeting of the Association a paper "Certain Thoughts upon the College Art Problem" was presented by Miss Alice V. V. Brown of Wellesley College, and one on "The Teaching of Drawing and Painting in the College" by Prof. Arthur Pope of Harvard University. If the members of the Art Division of the AMERICAN CERAMIC SOCIETY do not already know of these papers we would call attention to them, since they constitute a considerable body of expert opinion by many of the leading educators of the country in the art field.

On the subject of history, the College Art Association has had a number of valuable papers presented to it concerning drawings, paintings, and sculpture, which we need not stop to consider but pass on to one dealing with ceramics, an exceptionally important original study of "Antique Glass" by Gustavus A. Eisen (*Bulletin*, Vol. II, 1919, 87–119), which furnishes historical notes on the several periods of antiquity producing glass, a detailed and illustrated account of the technical steps employed in its manufacture, a key to the classification of antique decorated and mosaic glass, and a bibliography of the subject. Reviews of the following works on Greek vases have also been published: J. D. Beazley, "Attic Red-figured Vases in American Museums," Harvard University Press, 1918; J. C. Hoppin, "A Handbook of Attic Red-figured Vases, signed or attributed to various masters of the sixth and fifth centuries B.C.," two volumes, Harvard University Press, 1919; Mary A. B. Herford, "A Handbook of Greek Vase Painting," Longmans, Green & Co., 1919 (*Bulletin*,

Vol. II, pp. 42, 123, 178, respectively). At the twelfth annual meeting Prof. Homer E. Keyes of Boston urged the study of early American artistic crafts, specific mention being made of the glass industry and the beginnings of the potteries at Trenton.

Under the heading "technique and principles of design" may be mentioned a plea for "The Necessity of Developing the Scientific and Technical Bases of Art" by Edwin M. Blake (*Bulletin*, Vol. II, pp. 31–38), "Dynamic Symmetry—A Criticism" by the same author (*Bulletin*, Vol. III, pp. 107–127), "The Application of the Munsell Color System to the Graphic Arts" by Arthur S. Allen (*Bulletin*, Vol. III, pp. 158–161), and "Color Analysis as a Way to Develop Personal Choice in Color Grouping" by Clifford H. Riedell of Smith College. The last mentioned paper, presented at the twelfth annual meeting of the Association, was illustrated by a large number of diagrams in color. In connection with the paper of Prof. Pope, already mentioned, color studies by his students, following the system of Prof. Dennan W. Ross, were shown. Also Prof. Pope insisted on the value of a sound and liberal education to the artist, and in the matter of technical training for the painter pointed out the distinction between medieval times and our own. Formerly the artist was trained in an established workshop having well-defined methods based on traditions handed down from the past. Now those workshops have passed away and present day procedure must be based on rational study of the chemical, physical, and other factors involved. This is doubtless the best way, if carried out, but unfortunately much of modern painting shows both absence of ancient tradition and of any rational procedure to take its place.

Here should also be mentioned two other papers read at the twelfth annual meeting. "The Use of Autochrome Slides as Illustrations for Lectures" by Prof. Holmes Smith of Washington University, discussed the advantages and disadvantages of those slides and showed how truthfully they can render paintings in color. "Some Results of the First Year's Work in the Formation of the New Series of Photographs of Sculpture" by Prof. Clarence Kennedy of Smith College, makes report of an undertaking which has excited widespread interest on account of the splendid lifelike photographs of sculpture which he has produced. In the first place the piece of statuary is cleaned as completely as possible. Many ancient marbles carry various stains and incrustations which may, with care and labor, be removed without injury to the original surface. Then the piece is thoroughly examined by placing it in various positions and lights to determine which is the best to bring out its salient characteristics—trials which may take two or three days. Skilful photographing followed by painstaking development, printing, and mounting are necessary to the final excellent results. These details have been mentioned because it would seem there must be many pieces of artistic terra cotta, vases, and other objects of

ceramic art, both historic and modern, which might well be photographed, for purposes of instruction, by the careful methods of Prof. Kennedy.

While at Boston and Cambridge members of the Association were enabled to visit the Boston Museum of Fine Arts, The Fogg Art Museum and the Germanic Museum of Harvard University, the private collection of Mrs. John L. Gardner at Fenway Court, and the gallery of Mr. Desmond Fitzgerald in Brookline. Besides many masterpieces of painting, ancient sculpture and furniture in the Gardner Collection, there is a Roman pavement from the Villa Livia in the beautiful inner "Court" surrounded by the "Gothic Cloisters," two pieces of terra cotta by the della Robbias, and several quaint tile floors by Henry Mercer of Doylestown, Pennsylvania. Mr. Fitzgerald has a noteworthy collection of French paintings, a great number of water colors by Dodge Macknight, some interesting ancient Chinese porcelains, and a remarkable collection of Corean pottery of the Korai Period, dull gray green in color with white underglaze decorations.

Brooklyn, N. Y.

IMPORTANCE OF PURE RESEARCH ON GLASS IN AMERICAN UNIVERSITIES

By Alexander Silverman

ABSTRACT

A discussion of the importance of a systematic study of the properties and reactions of chemical substances utilized in glass manufacture. A long list of problems in pure research is given, most of which would directly benefit industry through their practical application. The organization of a glass manufacturers' association for the purpose of subsidizing this research in colleges and universities is recommended. The value of research to corporations and other associations is indicated.

One of our largest manufacturers of electrical machinery maintains a research laboratory which has cost millions of dollars. As a result, metals and alloys, insulating materials, etc., have been studied for their specific properties, and these have been listed and cross-indexed so that any department in the factory may look up a material of certain properties and utilize it without delay. This research department must pay, or the company would not continue to employ high-salaried investigators and spend such vast sums on the researches. It is a well-known fact that two German dye manufacturers employed over one thousand chemists before the war, many of them Ph.D.'s. Although only five per cent of the problems undertaken were successful, the companies were able to pay over twenty per cent per annum to their stockholders. The industries cited are unquestionably better able to spend considerable sums for the maintenance of research laboratories than any of our glass manufacturers, except a few of the larger corporations. The glass industry as a whole, would, however,

derive appreciable benefit, if each company through a "Glass Manufacturers' Association," contributed a moderate sum towards the maintenance of pure and applied research. This has already been attempted by manufacturers of refractories, paper, paint and other materials, and the fruitful results have added to the profits of many of the members of such associations. In some instances, individual companies, still retaining membership in the association, have installed private research laboratories at their plants.

Costly instruments of precision are required for careful investigation. These are found in the laboratories of chemistry and physics in our colleges and universities. Other equipment, such as melting furnaces, is generally lacking. Thousands of students enroll annually for study towards the advanced degrees, Master of Science and Doctor of Philosophy. Many of the professors of chemistry and physics are men of long experience and mature judgment. The salaries required to employ these men would prove prohibitive in most of our glass plants. A "Glass Manufacturers' Association" receiving nominal contributions from a large number of members could arrange to endow fellowships at $1000 each in several of the best universities, and by defraying the cost of installation of furnaces and accessory devices, promote pure research on glass which would prove of incalculable value to the industry as a whole. Professors in charge of science departments will carefully choose men to handle these problems and the men, in turn, will naturally take an interest in the field for which they prepared, so that glass manufacturers who want to employ them later, may secure the technical service of scientists, well trained in the fundamentals of glass science, and receptive to practical plant training, operation and control work. Today, when the manufacturer wants a chemist or physicist who has some knowledge of the glass field, our educational institutions must of necessity say "we haven't one." State appropriations and private endowment funds hardly suffice to meet the universities' needs in training students in the ordinary fundamentals, to say nothing of specialized training.

Would it prove of interest and value to your company to know that you could substitute this material for that one and lower the cost of manufacture while still maintaining the quality of the ware? Would you substitute another material to improve the quality of the glass at the same cost or even at a slight advance? Would you eliminate stones, cords, striae, blisters and seeds if you could? Does the color of your glass change at times, though you have not changed the quantity of coloring or decolorizing agent? Wouldn't you like to know how much of this or that material is lost in melting the batch? Would full economy in the operation of your plant seem desirable? Wouldn't you change your batch to prolong the life of pots or tanks? Does the size of your cullet pile worry you? Would you learn how

to reduce it? You may think that these are plant problems, but in reality they are pure research problems as well, and the fundamental principles on which their solution depends are applied "every day, in many ways" in the graduate departments of our universities, ultimately proving of value to industry.

Forty of the eighty-eight known chemical elements have been used (either free or in their compounds) for glass making. Many of the others may never have utility in the field. Some undoubtedly will. But what of the forty? Do we know all about their application or that of their compounds? Hardly. Let us stop to enumerate a few of the things we do not know.

What portion of the original sodium carbonate is lost in melting an ordinary soda-lime batch? How much more, if any, is lost when we melt the batch with cullet? How do variations in lime or silica content of the batch influence the alkali loss? How do variations in furnace temperature affect it? How does the loss in pots, compare with that in crucibles or tanks? How does the melting rate or size of container influence loss? What influence do various quantities of alkali have on the container during the melt? What effect do they have on the finished product as to durability, permanence of bright surface and influence on contents of bottles, for example? We have very little definite information, yet soda ash has long been used in glass making, probably over 3000 years, if we include the natural soda employed in Egypt.

Some manufacturers employ limestone, which may be almost pure calcium carbonate, or contain magnesium carbonate up to forty-two per cent. What are the effects of variation in magnesium carbonate between these limits, on the glass? Is the same furnace temperature and duration of melt desirable? Does magnesia embrittle the glass and promote devitrification though it lowers the coefficient of expansion? Can anything be introduced into the batch to offset the undesirable properties produced in glass, so we may still use it and obtain desirable effects? Would it be better or worse practice for uniformity and economy to use burnt (quick) lime, or slaked (hydrated) lime, instead of limestone? Lime and limestone also have a long history in the glass industry, and we may know more about them than we do concerning most other materials, but much is still unknown that pure research would bring to light.

Sand is surely a common material. How do grain size and shape, beside composition, affect melting conditions? At which furnace temperature will the sand dissolve soonest? How does the fluidity of the flux govern this rate? Should we use equivalent amounts of various alkali compounds or substitute so as to retain the same viscosity in the flux? Should the viscosity be controlled by varying the amount of alkali, or by adding another chemical to retain desired alkali equivalent and still get proper fluidity?

What are the limits for sand, soda and lime in soda-lime glasses at various temperatures? The last question and a few similar ones have been partially answered through pure research.

How do common impurities affect glass? Is the alumina from sand and other raw materials and that dissolved from pot or tank walls beneficial or objectionable? If beneficial, would the introduction of alumina into the batch lower attack on refractories and prolong their life? Alumina permits of a higher lime content in glass. Does this improve the glass and what are the exact relations between the lime and alumina?

Is there any advantage in using red lead instead of litharge? How much niter is necessary in lead batches to prevent reduction? Can this be figured from the batch, or must the furnace gases be taken into account? Does the oxidation by niter continue long enough during the melt to do what tradition claims for it? Is lead reduced by the repeated introduction of the hot baits of blow-pipes? Can we find substitutes for pearl ash to insure resonance in fine flint table ware? Cannot resonance be estimated like refractive index and expansion coefficients?

Are certain chemicals compatible in the batch? Should lead and sulphur compounds appear together? Will selenium work in lead batches? What are the relative effects of coloring agents on soda-lime batches, lead-potash batches and other combinations used in making colorless glass? Is arsenious oxide an oxidizing or reducing agent in glass? How does it affect the color produced by iron compounds at various temperatures?

What are the proportions of aluminum and fluorine in compounds which will produce certain densities of color in batches of various types? How does the addition of zinc compounds, of boron compounds, of sulphates, of chlorides, influence the color? Are best results obtained in open or closed melting units? Why do glasses containing the same quantity of aluminum and fluorine strike when certain chemicals are employed in the batch and not when others are present? How is the composition of the glass related to dispersive power and light transmission?

How are annealing temperature and period to vary according to composition? How do annealing conditions affect color, glass surface, subsequent behavior in storage, etc.?

Selenium produces a red color in zinc-potash glasses in the presence of cadmium sulphide, arsenious or antimonious oxide and a reducing agent. How does the color compare with that obtainable in soda-lime, potash-lime, zinc-soda, and lead glasses? What are the best proportions for the coloring agents? Can alumina replace zinc? May other sulphides be substituted for cadmium sulphide? Will other cadmium compounds answer as well as the sulphide? Are selenium compounds better than the element? How do selenium reds compare with the colors produced by the related elements, sulphur and tellurium? Do fluorides affect the color? Is reheating neces-

sary to bring out the red? If not, how can it be eliminated? What influence does the reheating temperature and period have on color? Is the glass uniform in color, or are the edges yellow? How can the color be made uniform?

If we have so many problems to solve in the above given partial list of substances containing the few elements mentioned, one may readily imagine how this list can be extended by covering others and adding new elements and their compounds. America is held in renown for her wonderful development of the mechanical aspects of manufacture. She has forged on in scientific progress also. The investment of a little money in pure research in our colleges and universities to supplement that now conducted by the United States Bureau of Standards and the Geophysical Laboratory, would not only materially help our glass industry, but serve to place America in the lead in scientific research on glass. The published researches and work now in progress in the University of Sheffield, England, should serve as an admirable example.

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COLLOQUIUM ON FELDSPAR SPECIFICATIONS

Problems Involved in Writing Specifications for Feldspar[1]

BY EDWARD SCHRAMM

The work which the AMERICAN CERAMIC SOCIETY is about to undertake in developing specifications for ceramic materials calls to mind the analogous efforts in a wider field of the American Society for Testing Materials. Indeed, writing specifications constitutes the chief activity of the latter Society and we may learn a number of things from their experience and procedure. The first and most important is to go slow. The Committees having these matters in charge report proposed specifications to the appropriate division of the Society; these are first adopted and published as tentative and only approved as final after lapse of a considerable period of time and subjection to searching criticism. We could not do better than follow this procedure. If our SOCIETY is to make a serious effort to write specifications, it will be necessary for some of the members, presumably the Committee on Standards, to devote some hard study to the project. A symposium, such as we are holding, cannot be more than an introduction.

[1] See Howard C. Arnold, "The Polarizing Microscope as an Aid to Feldspar Standardization," *Jour. Amer. Ceram. Soc.*, **6** [2], 409 (1923); F. C. Flint, "Feldspar for Glassmakers," *ibid.*, p. 413; M. C. Booze and A. A. Klein, "A Rapid Means for the Determination of Quartz Content," *ibid.*, **6** [6], 698 (1923); "Feldspar Colloquiums," *Bull. Amer. Ceram. Soc.*, **5** [7], 78–101 (1922); **5** [8], 133–47 (1922); **5** [11], 269–95 (1922); "Proposed Tentative Feldspar Specifications," *ibid.*, **6** [6], 163 (1923).

Standard specifications are fully as useful to the producer as to the consumer since they tend to replace a multitude of individual specifications and reduce needless diversity of demand. The specifications cannot entirely take care of the question of *quality* since there are usually matters involved beyond their scope. Thus two foundries may produce gray iron castings which answer the chemical and physical requirements of a certain specification but superior technique in manufacture may render one product far better than the other.

Most specifications deal with manufactured products which are more or less under control. In the case of feldspar we must take the rock as nature provides it, modified of course by selection at the quarry and mill. We cannot, therefore, truly "specify" at all but can only choose what we want out of nature's storehouse. The basic study is, therefore, to find out what that storehouse contains. Every useful feldspar mineral should have a place in our scheme.

It is apparent that we are faced with the larger task of classifying the feldspars according to their ceramic properties. These properties, the most important of which is the fusion point, are determined in the main by chemical composition and degree of grinding. However, there may be other factors involved, such as variations in crystal form and the following question may well be raised: given two feldspars of nearly identical composition, can it be assumed that they will behave the same on firing? We know that of the high potash feldspars some are classed as soft and some as hard. In an abstract of a paper by M. E. Denaeyer,[1] we read that "the analysis of two microclines (triclinic potash-soda feldspars) is considered to indicate that they are built up of three separate components in solid solution." From the same source,[2] according to Gossner, "attempts to deduce from the chemical composition of a crystal the constitution of the corresponding molecular unit are fallacious. . . . By postulating the existence of a limited number of simple stable silicates as molecular individuals, the structure of more complicated silicates can be explained as due to combinations of these."

Leaving the somewhat speculative subject of the true molecular composition of the feldspars and its influence on their properties, we shall have to deal chiefly with chemical composition, grinding standards, and fusion point. It will probably prove best to restrict the chemical requirements to the alkali content, establishing different ranges for the several grades. Perhaps more important than the actual composition is the question of constancy; what variation is permissible from an agreed standard of composition? The methods of chemical analysis of feldspar are somewhat tedious but well established and reliable. We are fortunate in having on our pro-

[1] *Ceram. Abs.*, **2** [2], 12 (1923)

[2] *Ibid.*, p. 13.

gram two papers dealing with the application of petrographic methods to the problem. These are obviously quicker but it is a question whether they are sufficiently exact for the purpose.

Passing from the question of composition to that of grinding, we are on much surer ground. Probably the millers will be glad to do as much or as little grinding as they are paid for and it should not be difficult to establish several grades to meet the varying demand. The method of testing must also be agreed upon. The writer believes that washing through a screen of 250-mesh or finer is the most practicable procedure. The coarser screens do not adequately distinguish between poorly ground and well ground materials.

As a supplement to the chemical composition and grinding standards we may include a fusion test under carefully regulated conditions. This test is especially useful where the consumer is drawing on one source of supply as it gives a simple means of detecting sudden changes. It is questionable whether we have the data needed to correlate this test with chemical composition for the different feldspars.

In the foregoing brief survey, the writer has attempted to state the problem and it is hoped that the papers and discussion to follow will lead us nearer to a solution.

Proposed Tentative Feldspar Specifications[1]

Since the last Annual Meeting the Committee has been in correspondence with several producers and large consumers of feldspar.

The consumers are a unit as regards specifying the characteristics of the feldspar they purchase. As might be expected the producers see many difficulties in the way. However great and real these difficulties are, they must be surmounted to the end that the industries which give to feldspar its value may enjoy a greater measure of freedom from uncertainty and consequent loss.

In the September, 1920, *Journal*, "Specifications for Commercial Feldspar and Flint," by A. S. Watts, was published. His noteworthy contributions have assisted all, particularly the thorough work published as *Bulletin* **53,** of the Bureau of Mines, 1913, on the "Mining and Treatment of Feldspar and Kaolin."

It has become the practice of certain manufacturers to use more than one kind of feldspar ground to various degrees of fineness. Feldspar millers are now grinding finer than was the common practice even two years ago. In this connection a series of valuable suggestions has been received from G. E. Sladek calling attention to the fact that, at the present time, feldspars of definitely different composition and definitely different grinding characteristics are in use.

[1] *Bull. Amer. Ceram. Soc.*, **6** [6], 163 (1923).

In view of the above it is suggested that Prof. Watts' specifications be amended as shown in the Feldspar Specifications.[1]

Discussion

SECRETARY TREISCHEL:—The first point is in regard to the sampling of the material.

1. The Sample.—In sampling car-load lots, equal amounts should be taken from at least five different points in the car, no two samples being taken within five feet of each other. In sampling from a bin, five separate samples shall be taken from different portions of the bin and not more than two from the same level. The total sample shall not be less than ten pounds.

A MEMBER:—Does it specify the weight of sample?

C. C. TREISCHEL:—Not less than ten pounds. Two pounds from each place.

F. S. HUNT:—Would that prevent the use of an automatic sampler?

A. S. WATTS:—The proposed specification provides for sampling from at least five different points. Where an automatic sampler is used 40 samples can be taken as easily as five. But where there is no automatic sampler it is very simple to get five samples from a carload.

F. S. HUNT:—At least five samples?

C. C. TREISCHEL:—Yes.

F. C. FLINT:—What type of automatic sampler is used?

T. A. KLINEFELTER:—A simple way is to take a brass tube about two feet long, two inches in diameter and put a device on the end so that it permits the tube to fill as it is pushed down, and closes as the tube is withdrawn.

C. C. TREISCHEL:—It is proposed in this specification to have four grades or classifications according to their chemical composition: Grade A with potash content above 10%, and soda content below 3.6%, and total lime and magnesia content below 0.75%; Grade B with potash content above 9%, and soda content below 3.2%, and lime-magnesia content not above 1%; Grade C with potash content above 7.8%, soda content below 2.8%, and a lime-magnesia content not above 1%; Grade D with a potash content not above 3%, a soda content not below 7%, and lime-magnesia content not above 1%; Grade D is to cover the soda feldspars.

R. B. LADOO:—Might I suggest that that gradation does not cover a type of feldspar sometimes met, where the potash and the soda are more or less equal? There should be some combined classification which would show total alkali content so as to take care of these mixed feldspars; for example, one with 5% potash and 5% soda, which is possible. This specification would not cover that at all.

J. M. MANOR:—The feldspar used in the glazes, though it has the higher soda content, is the higher-priced feldspar; necessarily so on acccount of its alkali proportion.

[1] *Op. cit.*

J. P. RODGERS:—The point brought out by Mr. Ladoo is one that ought to have careful consideration. In the short reading I have had of these Specifications it has occurred to me you are treading on your own toes. Of course, as far as we feldspar men are concerned, we can only sell what the potters want and if we have nothing in accordance with their specifications we cannot sell it. But, as Mr. Ladoo says, there is a considerable amount of feldspar on the market not covered in any of these. I believe that 25% of the manufacturing potters are using a feldspar more nearly $8^1/_2$ potash and 4 soda.

When you try to fix the proportion of alkalis you are getting into deep water. I have seldom met with two potters who agree what that proportion should be, hence I really think you had better leave the selection of proportionate contents of alkalis to the individual potter.

For instance, possibly a year ago, I had to make a pilgrimage to the eastern shrine of pottery. I went there not to sell but to get their viewpoints. One man (well-known in the AMERICAN CERAMIC SOCIETY) asked me if I had anything new in the feldspar line. I said, "No." Then he said, "Why come here?" I said I came to see if he held the same views as to the composition of feldspar as he formerly did. He said, "I do, and I will say to you that the man who buys feldspar containing 1% of soda is a fool. The man who buys it containing 3% is a fool of a greater degree.

This potter is a very able fellow, yet that is his opinion. To another potter (to whom I do not sell feldspar) I said, "How does this feldspar you are using analyze?" He said that he never asked me for the analysis of my feldspar when purchasing from me and that he had not asked this man. He did not care what it analyzed.

This latter fellow is a successful manufacturer of hotel china, to whom I sold feldspar for twelve years. In those twelve years I got into trouble with him five or six times. Every time it was because the exigencies of the crude feldspar market forced me to change my mix from the usual $8^1/_2$ potash and 4 soda. That fellow was only one of a very considerable number using something approximating that mix.

I think the key to the situation is entirely missed when feldspars are grouped or classified on the basis of character of alkalis. If it is fixed on the maximum silica content of the feldspar there is a long step taken toward the solution of feldspar problems.

B. E. SALISBURY:—It would be a fine thing if feldspar could be produced strictly according to specifications, but most potters would like to know what they are getting when they get a carload of feldspar. If some way could be found under which a producer of feldspar would guarantee that his feldspar would answer a certain analysis which he published, with permissible variation in the various ingredients, we shall have gone a long way in advance of anything we have had before. Then it is up to

the individual potter, to select what he needs. He would have the assurance that he would get the same feldspar as long as he got it from one source. The feldspar producers should be able and willing to do a practical thing like that. We cannot hold them down to points impossible for them to reach. There are natural physical limitations which control the product of each feldspar producer. But if we know what we are buying, we could take what we want (at least, that is the way we feel in our company).

CHAIRMAN PENCE:—Following that suggestion of Mr. Salisbury's I take it, that, if the producer gives us an analysis of his feldspar, guaranteeing that it shall not vary beyond specified limits, we should be satisfied.

B. E. SALISBURY:—That would be my idea.

J. M. MANOR:—We could go further: Exact from the producer a statement as to just where his feldspar comes from, the particular mine, and also that when conditions vary he shall not without due notice substitute a different feldspar. I have heard this talk about changes in a given feldspar. As a general proposition, these changes are not made, but if a mine is exhausted of one kind and the producer decides that another mine runs about the same, trouble will probably follow if he attempts to slide that in.

C. M. FRANZHEIM:—Can you tell me on what basis these varying alkali bases are to be fixed? Is it on the basis of the way it occurs or on the pottery requirements?

CHAIRMAN PENCE:—I think it was indicated in the opening remarks that these analyses are attempts to classify. It is really identification rather than grading according to quality. However, Mr. Salisbury has indicated that we could avoid confusion by simply asking for the analysis and specifying that it should not vary beyond certain limits. The consumer would then select what he wants.

C. M. FRANZHEIM:—Has any attention been paid as to whether these proportions really exist?

H. SPURRIER:—Yes, you will find these quantities correspond to the feldspar on the market.

A classification rather than specification is what is wanted. I am glad to see the weaknesses brought out. We need something that will cover the quantitative relation between potash and soda.

C. M. FRANZHEIM:—I find a great weakness in these proposed specifications. There is no alumina content. The value of a feldspar is not in its potash content but its relation of content of alumina to that of potash and soda. One customer told me he bought feldspar only for the high potash. He overlooked the fact that the alumina content had some bearing. I see no mention of that. There is great value in the relation of the potash and alumina which should be considered.

F. S. HUNT:—Regarding the alkali percentages: A fifth class to include those feldspars which come between Class D and Class C could be provided,

called Class E, and include all feldspars in which the relation of the soda and potash is between those two limits. That would include all feldspars regardless of the relation between the soda and potash.

CHAIRMAN PENCE:—These specifications are in process or in progress. We do not expect any answer today. The Standards Committee will benefit by the expression of your opinions and knowledge. They will then do further work on the Specifications.

C. M. FRANZHEIM:—I should like to see the Committee investigate the relation of the alumina content with regard to the potash content.

H. SPURRIER:—The alumina content is automatically controlled. Normally speaking, the existence of the alkali controls the alumina.

C. M. FRANZHEIM:—I have seen feldspar with $8^1/_2$ potash that was softer than another having 14% potash, because the alumina content was low. The value of feldspar is therefore not determined alone by its potash content but the proportions between the content of alkalis and the content of alumina.

T. A. KLINEFELTER:—I have made the same observation as Mr. Franzheim relates but in this the soda content was higher. I thought it was of the proportion of the soda to the potash feldspar which made a eutectic. I believe with Mr. Spurrier that the potash content largely controls the alumina content and this softness depends on the proportion of soda to potash. It has been my experience that the total alkali could be low if the soda content is somewhat high.

C. M. FRANZHEIM:—A feldspar low in soda, high in silica, about 70 or 72%, and low in alumina will be a softer feldspar, visibly softer than the feldspar of 13% of potash and high in alumina. It is the relation of these various things to each other that has a big bearing on the value of the feldspar. The high potash feldspar does not necessarily belong in Grade A.

According to these proposed specifications for grading, in the minds of my clients, I would be selling Grade B feldspar, a suggestive situation which I wish to avoid. It is because of the psychology involved in any classification of this sort that I would avoid selling B feldspar. I believe my feldspar is Grade A, commercially speaking. I am speaking from a commercial standpoint and of the impression a classification of my feldspar as "B" would have in the minds of my customers. I do not want a classification and have my customer ask me, "What grade are you selling?" and have to say, "Grade B." He would say, "You are asking high prices for Grade B."

If the trade would understand the purpose of this classification it would be all right, but most of the buyers neither could nor would.

C. C. TREISCHEL:—How would you prevent that psychological idea on the part of the consumer.

C. M. FRANZHEIM:—Grade A would be the best, and B would be second grade. We, here. would understand it differently but to a purchasing

agent and also to many practical plant men Grade B would stand for an inferior product. I am thoroughly in favor of this classification from the viewpoint on which it was drawn but to the consumers Grade A (10% and above potash) would mean that this was the most valuable feldspar whereas I think you would find that it is not in all cases. High potash does not mean greater value.

C. C. TREISCHEL:—That is quite true, but what we need is some assistance for the Standards Committee to work on.

C. M. FRANZHEIM:—That is a hard problem. I should like to see the Standardization Committee, before they adopt anything, visit the various mines and see their problems. They could see what we are up against every day. I am sure they would be welcomed, and they could work with the men who select the feldspar.

B. E. SALISBURY:—I appreciate the psychological effect of this grading. Why not call the best feldspar Grade D?

F. S. HUNT:—Instead of class names, use the same system which the pencil manufacturers use. Classify the high potash feldspar as "K," high soda as "N," your medium grade as "KN," your second grade of potash as "KK," or something of that nature. That would relieve the situation altogether.

A. S. WATTS:—I should like to point out that if a feldspar contains 9% of potash, and $3^1/_2$ of soda, there is $12^1/_2$% of alkali. That feldspar is not going to run over 17% of alumina, is it? Have you seen any running over 18 or 19 with the potash between 9 and 10 and the soda less than $3^1/_2$%?

C. M. FRANZHEIM:—It will not go over 18.

A. S. WATTS:—If the total alkali and alkaline earth is not over 14% and the alumina is not over 18%, there must be 68% of silica. We know that a moderate amount of excess silica makes a softer feldspar, *i. e.*, feldspar that will fuse at a lower temperature.

We buy feldspar for its flux value. If I have a pure feldspar unmixed with flint or quartz with 14% alkali in the ratio of 10 and 4, I can introduce silica as flint bought at a very much lower price than that of feldspar, hence lower than if incorporated with the feldspar. On this basis the high alkali feldspars would properly be of higher value. This, however, is not the solution of the problem we have here.

I do not think the question is how much alkali or soda or alumina they shall contain as it is to find out what we are going to establish as a standard. The consumer as a rule has his own definite idea of what is meant by a No. 1 and No. 2 feldspar. He evidently thinks a No. 1 feldspar is a more or less definite article. I realize that the producer is going to object to classifying his feldspar if it puts it into a class that appears low. That is normal and fair. I believe, however, that the scheme of classifications here proposed is logical. It does not mean you will sell by it. It simply means that when

you say your feldspar is in a certain grade the man buying it has a general idea of its analysis, that is, this classification gives an interpretation to the analysis placing the feldspars into groups having a definite limit of permissible variations in composition. It seems to me that a fair classification can be based on reasonable limits of compositions.

I believe, also, that a classification based on the fluxing value of a feldspar can be established. As we know, the standard cone is constant within very small limits, and if a classification is based on the cone temperature at which the feldspar will fuse by itself and will fuse when mixed with 10 or 20% of added flint, I believe the feldspar producer and consumer both would have valuable information. And it is easily obtained. You do not need a week to make the fusion test of feldspar.

One word about the potash-soda content. There are two feldspar producers present who are prepared to furnish a feldspar with 8% of potash and 4 or 4½% of soda. One of these feldspars is standard. Is this a blended feldspar?

J. P. RODGERS:—It is a natural blend.

A. S. WATTS:—It seems to me we must make a distinction between mill blended feldspar and a natural blended feldspar. A blended feldspar will vary in ratio from 5% of potash and 7% of soda to 7% of potash and 5% soda. We should differentiate between natural potash feldspars in which a small amount of soda is naturally present reducing the potash in the rock, and the mixture which is made up of a potash and soda feldspars intimately associated. I think we ought to call that a blended feldspar or by some other name to differentiate from the perthite in which potash feldspar is replaced in rock by soda feldspar in small amounts.

SECRETARY TREISCHEL:—The next points were "Physical Properties and Test:"

1. Color and Specking:

Bearing in mind the variety of wares in which feldspar is used and the various standards as to color and specking potters find it necessary to establish, it is considered desirable to leave this matter open to agreement between vendor and vendee.

In other words, if a buyer gets up a set of specifications and bases his specifications on this classification, he can put in almost anything he wants.

2a. Fineness of Grain:

One hundred grams of the sample, after being dried to constant weight at 105°C shall be tested for fineness of grain according to the process set forth in paragraph 2b and the residues on the various sieves shall not exceed the maxima as set forth in the following table:

Screen No.	100	140	200	270	325	Total residue
Grade 1.....	0.25	0.5	1.25	2.0	5.0	9%
Grade 2.....	0.50	1.0	2.5	4.0	6.0	14%
Grade 3.....	0.75	1.25	3.75	5.0	8.0	18.75%

For the screen analysis the Standard Screen Scale sieves are used, the openings increasing in the ratio of the fourth root of 2 or 1.189, as recommended in *Year Book*.[1] All percentages are on the dry basis.

Is there any discussion on the fineness of grain as to those grades? In making up a specification from a classification like this you could have grade "K," and according to fineness, "K-1;" or grade "K," according to fineness, "K-3," which would be a little different. A thing of this sort is very flexible.

R. B. LADOO:—I notice that you specify residues on many different screens. That would be almost impossible to approximate in practice because the residues on various screens depend not only on the physical characteristics of the feldspar but upon the method of screening. If you specify residues on five different screens it is much like trying to draw a circle between five different points. You cannot do it. You should specify a limiting screen. For example it might be specified that all should go through 80-mesh (limiting screen) and $98^1/_2\%$ should go through 200-mesh. With these limits set, the residues on other screens will be automatically regulated by the method of grinding and the physical properties of the feldspar.

C. C. TREISCHEL:—That point seems to me to be well taken. I have found that same variation in material coming from continuous grinding and from batch grinding.

H. SPURRIER:—These are supposed to be maximum figures. You could hardly expect a hard and fast specification. It was expected a good deal would be altered. These quantities come within the limit of my own experience as far as that goes. It was impossible for me to go specifically outside of that. My experience is not wide enough. I want it corrected, amended or rejected. Whichever you do, it is open to objection. It is desirable to have intermediate sizes and to know about them and if you only cite limiting points you are escaping or missing something that is very useful. At the same time I agree you are trying to draw a circle in the five points. Whichever you do you have to draw our circle inside the five points.

P. H. BATES:—It is a matter of carrying the specifications into effect. Screens will differ. Take some with the Bureau of Standards certificate and they will give you half a dozen different results. With the same sample on the 200-mesh screens there was a difference of 5%. That is a difference in the operators. The A.S.T.M., which are the standard, allow a tolerance of 2% on the 200-mesh screen. But that specification said 80% should pass the 200-screen. An operator who got 78% would pass it. Unless you take that into consideration you are going to have considerable difficulty

[1] *Jour. Amer. Ceram. Soc.*, **5** [4], Pt. 2, p. 36 (1922).

and the only person to make anything out of it will be the referee laboratories.

A. A. KLEIN:—Screens which check first will vary in time just from use.

J. M. MANOR:—That agrees with my observations. I think it would be a more fair proposition if Grade No. 1 on screen No. 140 were changed to .7 of 1% and 200 changed to 2%, on the basis of what it has been customary to furnish with satisfactory results to the trade; that is unless there is a desire to have it still finer than what they have been using.

A. S. WATTS:—We find as has been stated, that in the course of time screens will deteriorate but we have not found that that was extremely serious and I believe that by introducing a moderate tolerance you will not have a great deal of difficulty.

We have not been able to justify the use of more than three screens. I think three screens would suffice. With 100- or 80-mesh and the 200 and 325 a classification would be obtained which, with a reasonable tolerance, would be sufficiently accurate. The main thing in this screen classification is to have an operator of sufficient training or experience.

F. V. DRAKE:—I think you will find that the aperture in the screen made by the different manufacturers of screen, whether it says 200 or whatever it is, is controlled entirely by the diameter of the wire used in the manufacture of the screen. In the screening of your material the diameter of the wire used gives the aperture through which the material passes. You get a different gage wire and in that way you get a different aperture in your screen.

H. GOODWIN:—We find grinding plays an important part. This is one thing to be considered; the denser a semi-porcelain body the greater will be the tendency to dunting in kilns, and I suggest that in making up the classifications that this be taken into consideration. Of course, this can be overcome in part by proper balance in other body materials, or by giving kilns sufficient time to cool properly before opening up, but in these days of speed, kilns cannot be thrown over from one day to another in drawing, hence, the necessity of considering the fineness in grinding.

H. SPURRIER:—I propose that the schedule be amended to cover, say 6% plus. In other words, we have here what is desired and we accept 6% beyond that for each screen. For instance, on the 100-mesh, Grade 1, we have 0.25. We would tolerate 6% on the .25; or (25 × 1.06) or 0.265, which in the total will amount to more than is specified here. That would be enough to take care of the personal factor in making the tests. It is very difficult to take care of that. But a reasonable amount of care is presumed in all these things.

G. E. SLADEK:—We have conducted screen tests on all our flint and feldspar for ten years and the boys who do that are in high school. We showed them how and we found that, having two boys run the same tests,

we got little variation. We checked them with a standard. These screens have been used for some time and we find there is very little variation due to wearing. I think if the screen tests are conducted with any reasonable care you can get very accurate results on carload shipments.

R. B. LADOO:—The method of making the fineness test, as specified, seems unduly complicated. It is suggested that a simpler and probably equally accurate method is that used in the Washington Office of the Bureau of Mines. The procedure of screening is the same as that described except that the material is washed through the screen by means of a water spray from above instead of by splashing from below. A rubber tube is attached to a water pipe and a gentle spray made by pinching the end of the tube together with the finger. This method of sieving is more rapid than that recommended in the specifications and there is no danger of loss by slopping or by overflow. By this method all lumps are easily broken up and there is no danger of forcing the screen wires apart if a gentle spray is used.

SECRETARY TREISCHEL:—The next item is:

3. Moisture Content:

Unless otherwise specified the purchase price shall be based on moisture free material and the moisture content shall be determined as follows: 50 grams of the sample (paragraph 1) are carefully weighed out as soon as possible after sampling, and placed in an oven where a temperature between 105°C and 110°C is maintained with proper ventilation till the sample ceases to lose weight, and the loss in weight shall be calculated to per cent of the dry weight and so reported.

In case a suitable chemical balance is available the moisture test may be determined on a 5-gram sample.

Anything with reference to that on moisture content?

T. H. SANT:—I believe that was brought up a number of years ago. Most of the grinders will agree that it is almost impossible to load absolutely dry feldspar on account of the dust. You could not get workmen to unload it and you would not want it unloaded. Would not 2% moisture be acceptable?

C. C. TREISCHEL:—This classification does not restrict either the producer or the vendor to any certain water content. It just mentions the fact that purchase is desirable on the dry basis.

4. Fusion Behavior:

Test cones of the feldspar shall be made of standard dimensions, *i. e.*, $2^{7}/_{8}$" high (75 mm.) by $^{9}/_{16}$" (15 mm.) across the base of one face. The use of an organic bond such as dextrine or gum arabic, is permissible to ensure cones retaining form prior to fusion, but such added material must burn out completely and not affect the color of the fired material. The fusion behavior of the different feldspars shall be as follows for the grade 2 grind:

Grade A Feldspar shall fuse with or before Orton Cone 9
Grade B Feldspar shall fuse with or before Orton Cone 8
Grade C Feldspar shall fuse between Orton Cones 7 and 8
Grade D Feldspar shall fuse with or before Orton Cone 7

A MEMBER:—What of the potter who claims his maximum cone test is cone six?

J. B. SHAW:—Does this require that the fusion test will be made according to the test as adopted by the Standards Committee?

C. C. TREISCHEL:—All specifications from the SOCIETY will be referred to the Standards Committee and they will put in such things.

J. B. SHAW:—I asked that because it is a known fact that the cone at which the feldspar will fuse depends very largely upon the atmospheric conditions of the furnace and the time of fusion. It is necessary to specify most carefully those conditions before you could adopt anything very rigid in this matter.

C. C. TREISCHEL:—That point should be considered by the Committee in revising these classifications.

The next item is "Shipping:"

5. Shipping:

All material purchased under these specifications shall be shipped in clean closed cars.

6. Rejection:

The purchaser reserves the right to reject material which does not conform to the above specifications in every particular and to return rejected material to the vendor for full credit at price charged f.o.b. point of delivery specified by purchaser.

I am afraid that is going a little bit beyond a scope of a classification which is to be used as the basis for specifications and I personally would object to seeing this in a classification put out by the SOCIETY.

R. B. LADOO:—I have not noted any provision made for decisions on either analyses or screen tests or anything else.

A. S. WATTS:—Do the fusion temperatures indicated for Grades A, B, C and D line up with the compositions of the same data? I question whether a feldspar containing 10% or more of potash and 3.5% of soda and fusing at a temperature of approximately cone 9 could be diluted with flint until it had a composition of 8% potash, 2.5% soda and would fuse between cones 7 and 8. I do not believe that you would get that lowering of the fusion temperature due to simple dilution by flint. Can anyone on the Committee tell me if these tests have been carried out?

H. SPURRIER:—Not on feldspars of this composition, but closely related compositions and some of them taken from your own writing on this. I drew very freely on that, as on your specifications.

J. P. RODGERS:—The albites will fuse on cone 6, but a year ago I heard a member of this SOCIETY connected with the Terra Cotta Division state in the court room, under oath, that they would fuse at cone 3. I do not know whether they will or not. I have had tests of them made where they were well fused at cone 6. I never saw anything better than that.

A. S. WATTS:—Is it not true that albites contain a relatively high content of lime and magnesia?

J. P. RODGERS:—The Atlantic Terra Cotta Company told me that these particular albites contained about $2^1/_2\%$ of magnesia and lime.

J. M. MANOR:—With regard to the question just raised by Mr. Ladoo: How are these disputes going to be settled as between the producer and receiver? Both think they are right and both may be honest. How will it be settled?

C. C. TREISCHEL:—I think this whole matter will be taken up during the year. We want to take it up on the coöperative basis between the producer and consumer. These classifications have been made up in great part from the viewpoint of the consumer. This matter of variation in feldspar, of the desirability of classification and specification has been before us now for about three years. The only group who seems to have gotten anywhere have been the consumers. We have always welcomed the producer to get in and it has been our desire to have the producer present something definite. He will be requested to do that during the coming year, so that things of that sort will be worked out and a final classification presented possibly this year.

F. S. HUNT:—I should be very glad if the producers submit letters giving their ideas in writing. We have not had their opinions in writing to work on. We have had analyses, of course.

W. A. HULL:—I have been during the past year Chairman of the General Standards Committee of the SOCIETY and I am willing to accept full responsibility for the fact that these standard specifications were presented to the White Wares Division in present form to go through a process that specifications ought to go through in the Standards Committee.

Mr. Spurrier has done what I consider a good job for a one-, two- or three-man job, but Mr. Spurrier will agree with me that it was not a committee job. This is not as it should be. The fact is that if this SOCIETY is to work on specifications we must have Standards Committees that are large enough and representative enough to represent the best thought of all interests in the Division. A one- or two-man committee or four-man committee so situated that we can not get together and discuss these things and wasting the time of fifty men instead of ten or twelve is not right.

I wish to move that the White Wares Division has for the coming year a Standards Committee of not less than ten men, that producers be represented on it, that the Committee be selected if possible in such a way that it shall have a secretary who has stenographic help and shall be made up of men as far as possible whose concerns can afford to send them to at least three meetings in the course of a year, that this work that has been done here may be done up right during the coming year so that we shall

have the same sort of work that other societies that are really working on specifications are able to do.

The motion made by Mr. Hull was seconded and adopted, with the provision that the three meetings proposed should be held on dates other than those of the annual and summer meetings of the SOCIETY.

C. C. TREISCHEL:—Is there any formal disposition you want to take on this more or less formal classification you have before you?

It was moved, seconded and adopted that the proposed specifications for feldspar be referred back to the Committee on Standards for revision.

P. H. BATES:—Two other specifications I think have been referred to the General Standards Committee. I do not think they are any better or any worse than this one. Are you to reconsider your action on that and send them all back?

SECRETARY TREISCHEL:—I think as far as this Division is concerned we have done as much as we can on those. They have been referred to the General Standards Committee for further revision if they see fit.

W. A. HULL:—The General Standards Committee will make such disposition as seems best. They will probably refer them to the Standards Committee of this Division. The General Standards Committee is not so constituted that it can work on things of interest to but one Division. It is more coördinating. On any material of special interest to one Division the Standards Committee of that Division should do the work and put it forth in good form.

Do We Need Graded Specifications on Feldspar?

F. C. FLINT:—Is it necessary that we should grade feldspar according to its content of soda, alumina or silica, choosing certain percentages to call A, B or C grade? The mental implication that a B or C grade is inferior to an A grade is always present, which is a hindrance to the producer. The limits set for allowable variation inside of the grades is wide enough to be noticeable in use if shipments varied from one extreme to the other. Grading A, B or C according to cone fusions is only another way of stating that the feldspar fuses at cone 8 or 9. It would be simpler terminology to use the cones. Feldspar goes into such a variety of ware that it would be, strictly speaking, a difficult thing to make one specification of feldspar fit all kinds of material.

By way of example, coal would be graded A for coke use, B for producer gas, C for domestic, D for cannel. These grades could be made by analyses and soft coal is more uniform than feldspar, so could more easily be classified. But experience has shown it better to buy by analysis and size, stating the allowable limits of variation from the analysis.

Would it not be better to insist that the feldspar be purchased under speci-

fications giving its chemical analysis, grinding size, fusion, color, etc. This analysis to include not only alkalis, alumina and soda, but also all other elements appreciably present, for the magnesia and calcium contents affect its action as well as the chief ingredients. The fineness of grind should be expressed in a complete manner, showing the percentages on a number of screens, not percentage held on some one screen. The fusion should be given and also as soon as it is practical to do it, the content of other minerals, free silica or quartz, mica, hornblende, etc.

If a purchaser of feldspar obtains good results with any one typical specification, it would be very important to him to know what allowable free limit there should be in the various percentage constituents, sieve tests, etc.

The limits allowed by grading as proposed must be so wide that variation inside the classification could harm some products. To overcome this would make too many grades.

The discussion of specifications has brought out the fact that very few users of feldspar would use exactly the same specifications on the same ware and at the same time the producer would be hampered in trying to sell a feldspar which he could not change, but which specifications by their simpleness had made people try to use. In other words, if some large user of feldspar took a notion to a certain grade, there would be a tendency for other users to follow his grade, when probably their conditions would permit them to use another type of feldspar and some producers would be unable to fit the conditions.

Such a system would be more complicated in that each man would in a way set his own standard, but it would be simpler in that the standard is given directly in terms of constituents and not by an arbitrary set of grades. In glass alone there are a possible five grades which could be used. How about other products?

ACTIVITIES OF THE SOCIETY

WE ARE GROWING—BUT BRING ON THE TONIC

Thirty-two personal and seven corporations joined in support of the SOCIETY during the month of May 15 to June 14. There have been some resignations on account of withdrawal from the field of ceramics but a count of the membership cards checked by a ledger count shows that on June 14th the membership totaled 2030

The records are as follows:

	Personal	Corporation	Total	Net gain
June 14, 1923.....	1792	238	2030	203
January 14, 1923.....	1611	216	1827	338
January 14, 1922.....	1350	139	1489	

Comparison of the records from January to June 14th in 1922 and 1923.

	Personal	Corporation	Total
Net gain from Jan. 14 to June 14, 1923.....	181	22	203
Net gain from Jan. 1 to June 14, 1922.....	175	33	208

The SOCIETY lost 16 personals and 2 corporations during this last month by resignation. These losses are charged in so that the figures for June 14 are net as checked by actual count. This gives reason for the increase in 1923 up to June 14 being a little less than for the corresponding interval in 1922, but an enterprising man will neither give nor accept excuses for not doing better in this year of prosperity than was done in the slow year of 1922.

What are you, my fellow member, going to do about this? Do you feel the call to "be good to yourself" and to your neighbors? Will *you* not invite others to join?

The record of the individuals who have helped in keeping up the membership records for the period from May 15 to June 14 is as follows:

	Personal	Corporation		Personal	Corporation
H. Frost		1	Robt. V. Miller	1	
H. Goodwin		1	C. H. Modes	5	
W. J. Vollrath		1	L. M. Munshaw	1	
M. F. Beecher	1		C. L. Norton	1	
W. J. Benner	1		B. S. Radcliffe	1	
E. Hogenson, Jr.	1		Robt. Twells, Jr.	2	
R. K. Hursh	2		Otto W. Will	1	
R. N. Long	1		Office	14	4

Total 32 Personal, 7 Corporation

NEW MEMBERS RECEIVED FROM MAY 15 TO JUNE 14

PERSONAL

Anderson, Louie S., Terra Cotta, Ill., Head Kiln Burner, American Terra Cotta Co.

Arthur, Edwin P., 8 University Place, Columbus, Ohio, Chemist, U. S. Window Glass Co.

Barnard, Randolph H., 810 Henry St., Alton, Ill., Batch and Furnace Dept., Illinois Glass Co.

Brown, Henry C., 98 Fulton St., Woodbridge, N. J., Lab. Assistant, Federal Terra Cotta Co.

Burt, William I., Maple Grove, Ohio, Chemist, The Dolomite Products Co.

Carhart, Daniel L., 2326 Edwards St., Alton, Ill., Asst. Supt., Illinois Glass Co.

Dinsmore, Francis W., Imperial Porcelain Works, Trenton, N. J.

Feder, T. M., Special Representative, Illinois Electric Porcelain Co., Macomb, Ill.

Geer, John D., Newell, W. Va., Ceramic Assistant, Knowles, Taylor and Knowles Co., East Liverpool, O.

Gouin, Roland J., 1025 George St., Alton, Ill., Plant Chemist, Illinois Glass Co.

Hasselmann, Mario Fred, Caixa Postal 1546, Rio de Janeiro, Brazil (New York, P. O. Box 122, Station F), Industrial Manager, Comp. Constructora em Cimento Armada.

Hutchinson, O. C. K., 311 Prospect St., Alton, Ill., Industrial Engineer Illinois Glass Co.

Jeffery, Benjamin Alfred, 741 Edison Ave., Detroit, Mich., Vice-Pres., Champion Porcelain Co.

Kanhäuser, Dr. Frank, Chodov u Karlovych Varu, Czechoslowakia, Managing Director, Dr. Tonder and Co., Refractories Works.

Lahey, John A., Sewaren, N. J., Chemical and Metallurgical Director.

Lamar, Mark O., Worcester, Mass., Chief Chemist, Norton Co.

Lambert, Kenneth Coghlan, 208 S. 18th Ave., Maywood, Ill., Student.

Lava, Vicente G., Bureau of Science, Manila, Philippines, Physical Chemist.

Lyons, Okey A., 5345 Belvidere Ave., Detroit, Mich., Dressler Kiln Operator, Champion Porcelain Co.

Magid, Hyman Singer, 2639 Rice St., Chicago, Ill., Student.

Martin, P. W., Dry Branch, Ga., Pres., American Clay Co.

McKeown, Thomas H., 434 Laurie St., Perth Amboy, N. J., Chemist, Roessler and Hasslacher Chemical Co.

Norton, Frederick H., Mass. Inst. of Technology, Cambridge, Mass., Babcock and Wilcox Co.

Purcell, Buruette, 5811 Manchester Ave., St. Louis, Mo., Ceramic Eng., St. Louis Terra Cotta Co.

Reed, Gordon W., 407 S. Dearborn St., Chicago, Ill., Staff, *Brick and Clay Record.*

Robinson, Chas. J., 107 Gibson St., Canandaigua, N. Y., Efficiency Engineer, Lisk Mfg. Co., Ltd.

Schabacker, H. E., 917 W. 6th St., Erie, Pa., President, The Erie Enameling Co.

Stevens, W. P., Bibb Bldg., Macon, Ga., Manager, Dixie Fireproofing Co.

Stohl, L. A., Sun-Prairie, Wis., Box 725, Gen. Mgr., Standard and Specialty Porcelain Works.

Topliff, George C., 713 Main St., Alton, Ill., Foreman, Illinois Glass Co.

Walters, Durwood B., 1407–47 S. 55th Ct., Cicero, Ill., Special Representative, Chicago Vitreous Enamel Products Co.

Wenning, J. W., 3313 Allendale St., Corliss Sta., Pittsburgh, Pa., Supt. and Vice-Pres., The Vitro Mfg. Co.

CORPORATIONS

Alberhill Coal and Clay Co., 1204 Lane Mortgage Bldg., Los Angeles, Cal., James H. Hill.

California Pottery Co., 579 Mills Bldg., San Francisco, Cal., J. F. Creegan, Secy.

The Falcon Tin Plate Co., Niles, Ohio, W. T. Brangham, Gen. Mgr. of Sales.

The H. K. Ferguson Co., 6523 Euclid Ave., Cleveland, Ohio, H. S. Jacoby, Secy.

Los Angeles Brick Co., 514 Security Bldg., Los Angeles, Cal., Gen. Mgr., L. S. Collins,

Mineral Products Co., 50 Congress Street, Boston, Mass., Frank P. Knight.

Polar Ware Co., Sheboygan, Wis., W. J. Vollrath, President.

WHO'S WHERE IN THE AMERICAN CERAMIC SOCIETY

E. E. Ayars gives Little Genesee, N. Y., as his address for the summer.

Earl Baldauf, who received his B.S. degree in ceramics from Ohio State University in June has accepted a position with the National Tile Co., at Anderson, Ind.

Leo A. Behrendt writes that his address is the Midland Terra Cotta Co., 105 W. Monroe St., Chicago, Ill.

George Blumenthal, Jr., of Alfred, N. Y., has recently affiliated himself with *Brick and Clay Record,* 407 South Dearborn St., Chicago, Ill.

J. S. Brogdon writes that his mailing address is Box 1864, Atlanta, Ga.

Horace T. Brown has removed from Alton, Ill., to 65 Hampton St., Bridgeton, N. J.

Lawrence H. Brown has severed his connection with the E. M. Knowles China Co. at Newell, W. Va., and has accepted a position with the Findlay Electric Porcelain Company, at Findlay, Ohio.

Joseph L. Buckley has changed his address from Rock Island, Ill., to the Hipper Bldg., Des Moines, Ia.

Edward Burkhalter, ceramics student at Ohio State University, is living at 1978 Iuka Ave., Columbus, O.

H. D. Callahan has moved to 436 E. Long St., Columbus, Ohio, from Keyport, N. J.

H. M. Christman gives as his address, Wooster St. Ext., Massillon, O.

Hugh Curran, 1923 graduate at O. S. U., has gone to his home in Bakersfield, Cal.

James R. Goodwin, who has been living at 1267 Kenilworth Ave., Coshochton, Ohio, has moved to 921 May St., East Liverpool, Ohio.

John Grainer requests that his mail be sent to Spring Lake, Mich. Mr. Grainer has been living recently in Hamilton, Ohio.

S. E. Hemsteger who received his degree in ceramic engineering has gone to Mt. Clemens, Mich., where he is employed by the Mt. Clemens Pottery Co.

Carl G. Hilgenberg writes that his correct address is Baltimore, Md. Mr. Hilgenberg is President of the Carr-Lowrey Glass Company at Baltimore.

W. M. Hughes, third year ceramic student at O. S. U., will be in Zanesville, Ohio for the summer.

A. A. Johnson who has been in Chicago, Ill., is now living at 529 Christie St., Ottawa, Ill.

Robert M. King, graduate student in ceramics at O. S. U. for the past two years received his Master's Degree in ceramic engineering in June. His mailing address at present is Box 373, Maryville, Tenn.

L. P. Kraus, Jr., Vice-President of the Kraus Research Laboratories, Inc., 110 West 40th St., New York City, is at that address, having left the Babcock and Wilcox Co., at East Liverpool, Ohio.

Albert Krekel is living at 2903 Chelsea Terrace, Baltimore, Md.

Wm. H. Lucktenberg, formerly Vice-President and General Manager of the Burton-Townsend Co., at Zanesville, Ohio has resigned his position. He is spending the summer with his family at Buckeye Lake, Ohio.

T. Poole Maynard gives as his new address 220 Hurt Bldg., Atlanta, Ga.

Crawford Massey, ceramics student, O. S. U. will be at 555 Moxahala Ave., Zanesville, Ohio for the summer.

Paul R. Morris, chemist with the Pittsburgh Plate Glass Co., has removed from 300 E. 9th Ave., Tarentum, Pa., to Charleroi, Pa.

C. H. Myers, superintendant of the Utah Fire Clay Co., wishes to notify his friends that he can be reached at Salt Lake City, Utah. His recent address has been Murray, Utah.

Paul Q. Quay of Euclid, Ohio, has moved from Euclid Ave., to Lake Shore Blvd., opposite 246th St.

R. J. Riley of the Indianapolis Terra Cotta Co., Indianapolis, Ind., has removed to the Brightwood Plant.

John E. Sachs lives at 1221-A Main St., Evansville, Ind.

A. E. Saunders, formerly with the Oriental Art Glass Co., at Chicago has moved to Toronto, Can., where he is manager of the Jefferson Glass Co., Ltd., 338 Carlaw Ave.

William Senn is living at 808 W. Adams St., Sandusky, Ohio.

R. R. Shively, has moved from Fairmont, W. Va., to 311 E. Bean St., Washington, Pa.

Charles S. Shoemaker has notified us that he has moved from Arnold, Pa., to 328 Main St., Belle Vernon, Pa.

Paul Teetor, formerly ceramic engineer with the State Geological Survey, Lawrence, Kan., is now at 12 McKinley Ave., Trenton, N. J.

R. W. Widemann of Paris, France has removed to 30 Rue des Dames (XVII).

Carl G. Zwerner writes that his new address is 29 So. West 8th St., Miami, Fla.

NORTHERN OHIO SECTION MEETING[1]

Minutes

The 17th regular meeting of the Northern Ohio Section, AMERICAN CERAMIC SOCIETY, met the Cleveland Engineering Society at their rooms at Hotel Winton, Cleveland, Ohio, Tuesday, April 24th, at 2:30 P.M.

At this business meeting the resignation of Arthur F. Gorton as Secretary of the Section was accepted, and George H. Hays was elected to fill out his term.

The matter of committees was discussed and suggestions made. Since then, Mr. Zopfi has appointed the following committees:

Membership Committee

1. Robert A. Weaver, President, Ferro Enamel Supply Co., 818 Finance Bldg., Cleveland, O.
2. F. P. Nickerson, W. S. Tyler Co., Cleveland, O.
3. L. W. Manion, 1370 Greenfield Ave., S. W., Canton, Ohio.

Program Committee

1. L. D. Mercer, United Alloy Steel Corp., Canton, Ohio.
2. G. T. Stowe, Cleveland Builders Supply & Brick Co., Leader-News Bldg., Cleveland, Ohio.
3. Philip Dressler, 1551 East Blvd., Cleveland, Ohio.

Executive Committee

1. The Executive Committee will be officers and councillor of the Division ex-officio, and
2. A. S. Walden, National Carbon Co., Cleveland, Ohio.
3. William M. Clark, National Lamp Works, East 152nd St., Cleveland, Ohio.

[1] By George H. Hays, Secretary Northern Ohio Section. AMERICAN CERAMIC SOCIETY.

The meeting adjourned for dinner, and at 8 o'clock P.M. assembled to hear Ross Purdy's lecture before the joint session of this Section and the Cleveland Engineering Society. The lecture, "Ceramics—The Science and Engineering Involved," was well given and well received by the 100 present. Mr. Purdy held his audience spell bound for nearly two hours, explaining more particularly the close relationship between Ceramic Engineering and Mechanical Engineering. The discussion of this paper lasted over 30 minutes and many very interesting points were brought out. Mr. Philip Dressler was called upon and gave a short and interesting description of the development of the tunnel kiln in this country.

The Section has had many flattering comments about this meeting, especially from the members of the Cleveland Engineering Society who attended.

FORTY-FIFTH ANNUAL CONVENTION OF THE ILLINOIS CLAY MANUFACTURERS' ASSOCIATION AND CHICAGO SECTION OF THE AMERICAN CERAMIC SOCIETY

TUESDAY, MAY 8
LASALLE HOTEL, CHICAGO, ILLINOIS

Morning Sessions

Indiana-Illinois Division American Face Brick Association
Meeting—LaSalle Hotel, 10 A.M.

Illinois Drain Tile Manufacturers' Association
Address, "Where is the End of Drainage?" By J. A. KING.
Meeting—LaSalle Hotel, 10 A.M.

Illinois Paving Manufacturers' Association
Meeting—Association Offices in Chamber of Commerce Building, 10 A.M.

The Hollow Building Tile Association
Meeting—LaSalle Hotel, 10 A.M.

Afternoon Joint Session

Program

"The Relation of Sales to Manufacturing"
By ALBERT H. SHEFFIELD, Secretary, American Terra Cotta Company

"What the Buyer Must Be Shown"
By JAMES A. KING, Editor, National Reclamation Magazine, St. Louis, Missouri

"The Production of Green Colors on Face Brick"
By RALPH K. HURSH, University of Illinois

"Efficiency in Clay Haulage"
By THOMAS N. MCVAY, University of Illinois

Dr. M. C. Leighton, state geologist-elect was present and made a few remarks to the members of the Association.

The following officers were elected for the coming year:
James C. Reeves, President (Streator, Ill.)
W. H. Brosman, Vice-President (Albion, Ill.)
C. W. Parmelee, Secy.-Treas. (Urbana, Ill.)

The Committee appointed to consider the question of the amalgamation of the Illinois Clay Manufacturers' Association and the Chicago Section of the American Ceramic Society reported that the Committee had carefully considered the matter and after consulting with some of the older members of the organization, they had come to the decision that this is not an opportune time for such a plan. They recommended that the by-laws be amended to provide for an Executive Committee which shall consist of the officers of the Association and one representative from each state organization interested in the production of clay wares.

Meeting of the Chicago Section[1]

Following the meeting of the Illinois Clay Manufacturers' Association, the Chicago Section of the SOCIETY, started the evening with a dinner at the Hamilton Club. Desiring to give the Clay Manufacturers something recreational after a rather full day, the evening was turned over to entertainment for the great part, instead of a heavy technical session. A troup of entertainers kept the crowd of forty-five good fellows amused during the meal and for another hour with song and dance and fun in general. After a few words by Mr. Leighton, the new state geologist, this was followed by the projection of the well-known "Tribune Film," showing the manufacture of paper from the Canadian pulp-wood camps all the way down to "Andy Gump" and "Skeeziks." This splendid educational feature was enjoyed by everyone present, and many compliments have already been received. A short Harold Lloyd comedy entitled "Pay Your Dues," closed the program with a gentle hint.

Associations having joint meetings were:

Illinois Clay Manufacturers' Association
Indiana-Illinois Division American Face Brick Association
Chicago Section of the AMERICAN CERAMIC SOCIETY
Illinois Drain Tile Manufacturers' Association
Illinois Paving Brick Association
Hollow Building Tile Association

MEETING OF ST. LOUIS SECTION[2]

The St. Louis Section of the AMERICAN CERAMIC SOCIETY held a joint meeting with the American Society of Mechanical Engineers and the American Chemical Society at the Gatesworth Hotel, St. Louis on May 18, 1923.

W. B. Chapman, member of the AMERICAN CERAMIC SOCIETY and President of the Chapman Engineering Company spoke on "Fuel Saving in Modern Gas Producers and Industrial Furnaces," illustrating his talk by lantern slides and papier-mâché models.

An illustrated talk was given by Paul V. Bunn, General Secretary of the St. Louis Chamber of Commerce, the subject being "A Trip to Cuba, Panama and Costa Rica." Entertainment was also furnished by Station KFEZ, the new radio broadcasting station of the St. Louis Section.

Officers were elected for the year 1923–24 for this Section of the SOCIETY as follows:

Frederick E. Bausch, Chairman
W. J. Knothe, Secy. and Treas.
Geo. E. Thomas, Chairman, Membership Comm.
Chas. W. Berry, Chairman, Program Comm.

[1] By H. E. Davis, Secy., Chicago Section, AMERICAN CERAMIC SOCIETY.

[2] By W. J. Knothe, Secy., St. Louis Section, AMERICAN CERAMIC SOCIETY.

OBITUARIES

Members of the AMERICAN CERAMIC SOCIETY will regret to learn of the death of Ellis Gates, which occurred at his home in Chicago on April 25, 1923. Mr. Gates, son of W. D. Gates, charter member of the SOCIETY, was born in Hinsdale, Ill., in 1880. He received his education in the Hinsdale Schools, the Chicago Manual Training School and the Ceramics Department at Ohio State University. He was connected with the American Terra Cotta and Ceramic Company in various capacities at different times. He was later superintendent of the Denney-Renton Terra Cotta Company and the Seattle Terra Cotta Company. From there he was employed in New York by the New York Architectural Company, later in charge of their Pittsburgh office, then in Mobile, Chicago, Denver, and Santa Fe. During the latter years he was fighting his fatal illness, tuberculosis.

On Monday, June 11, the death of Mr. Joseph Keele of the Department of Mines of Canada, occurred at Ottawa. He was well known for his contributions to the knowledge and literature of the clay resources of the Dominion.

Mr. Keele was born 59 years ago at Birr, Ireland, and came to Canada at the age of 15. He was educated at the University of Toronto and for several years was a member of the staff of the School of Practical Science.

In 1898 he was appointed to the Canadian Geological Survey and performed worthy geological work, including notable explorations in the Yukon and the Mackenzie River regions. Later he devoted particular attention to the Pleistocene formation which finally led to his specializing in the study of clays in general and their utilization. To further fit himself for this, he took a special course in ceramics at Cornell University under Professor Ries with whom he collaborated on the investigation of the clay deposits of the Western Provinces.

For three years he carried on his laboratory work on clays at the University of Toronto. In 1915 he was recalled to Ottawa and was transferred from the Geological Survey to the Mines Branch, for the purpose of organizing the Division of Ceramics. In his capacity as Chief of this Division he was able to be of great aid, as an adviser, to the clay industry throughout the entire Dominion. In 1921 he was transferred, at his own request, back to the Geological Survey.

He leaves, as a record of his contributions to the knowledge of the clays of Canada, valuable reports on the clay resources of all of the Provinces.

He was a member of the AMERICAN CERAMIC SOCIETY, Canadian National Clay Products Association (Honorary Member), Canadian Institute of Mining and Metallurgy, Town-planning Institute of Canada, and the Ottawa Field-Naturalist's Club.

Mr. Keele was a man of broad interests. Although naturally a lover of outdoor life and spending much of his leisure in the open, he was keenly interested in art, literature and music.

Besides his recognized scientific attainments, his enthusiasm and breadth of view were an inspiration and a help to his fellow workers and assistants. In a quiet unassuming way he made many warm friends, and these will sadly miss him.

Official Personnel of Divisions—1923–24

	Art	Enamel	Glass	Heavy Clay Products	Refractories	Terra Cotta	White Wares
Chairman	F. H. Rhead	H. F. Staley	A. R. Payne	R. B. Keplinger	E. E. Ayars	A. F. Hottinger	F. H. Riddle
Vice-Chairman	J. C. Boudreau		J. H. Forsyth	F. T. Owens	F. A. Harvey		
Secretary	H. S. Kirk	R. R. Danielson	A. E. Williams	Amos Potts	R. F. Ferguson	R. L. Clare	C. C. Treischel
Committee on Research	F. H. Rhead	R. R. Danielson	E. W. Tillotson E. W. Washburn	R. T. Stull G. W. Shoemaker Paul E. Cox R. K. Hursh	M. L. Bell A. A. Klein E. N. McGee A. S. Watts Francis R. Pyne	E. C. Hill Major Gates	F. K. Pence
Committee on Standards (*a*) Tests (*b*) Products	W. J. Stephani C. F. Binns	(*a*) E. P. Poste	Tests: A. E. Williams; L. R. Milford. Refractories: D. E. Sharp; C. E. Fulton; W. F. Brown; A. S. Zopfi; G. Aurien; C. O. Grafton	P. H. Bates W. G. Worcester S. Geijsbeek W. P. Blair	R. F. Ferguson M. C. Booze R. M. Howe	(*a*) C. W. Hill D. F. Albery (*b*) J. L. Carruthers	(*a*) G. Sladek A. V. Bleininger
Committee on Data	Conrad Dressler	T. D. Hartshorn	J. C. Hostetter	H. G. Schurecht	L. J. Trostel F. A. Harvey A. S. Watts	T. A. Klinefelter	C. C. Treischel
Committee on Membership	H. S. Kirk	Karl Turk	F. C. Flint; J. B. Krak; R. R. Shively; G. H. Loomis; C. H. Modes; M. A. Smith; H. T. Bellamy; A. W. Kimes; R. F. Brenner; D. D. Schurtz; J. T. Keenan; H. W. Hess; F. B. Garrod; J. H. Forsyth	D. F. Stevens H. S. Vincent J. E. Randall	J. W. Hepplewhite E. H. VanSchoick Allan G. Wikoff	W. D. Gates G. M. Tucker A. L. Gladding	I. E. Sproat
Committee on Rules	F. H. Rhead		J. W. Wright	C. B. Harrop R. L. Hare W. W. Ittner	S. M. Kier R. M. Howe	R. L. Clare	August Staudt
Rep. on Committee on Nominations	Paul E. Cox	B. T. Sweely	W. F. Brown	C. F. Tefft		E. C. Hill	C. E. Jackson
Councillors	Mary G. Sheerer Hewitt Wilson W. D. Gates Frederic Carder Ira Sproat	H. C. Beasley W. C. Lindemann M. E. Manson D. F. Riess	J. C. Hostetter E. W. Tillotson D. E. Sharp J. Gillinder	C. F. Tefft		G. P. Fackt W. J. Stephani M. C. Gregory	
Com. on Papers and Program	F. H. Rhead				C. C. Bales J. S. McDowell L. C. Hewitt E. O. King M. C. Booze		
Education	J. C. Boudreau						

Personnel of Local Sections

	New England	Eastern	Pittsburgh District	Northern Ohio	Chicago	St. Louis	Detroit
Chairman	C. W. Saxe	Andrew Foltz	Alexander Silverman	A. S. Zopfi	B. T. Sweely	Frederick E. Bausch	F. H. Riddle
Vice-Chairman		Chas. W. Crane	Francis C. Flint	Emerson Poste	W. W. Wilkins		
Secretary		G. H. Brown	H. G. Schurecht	Geo. H. Hays	H. E. Davis	W. J. Knothe	
Treasurer			Thos. H. Sant				
Councillors		Chas. A. Bloomfield	Francis W. Walker	R. D. Landrum	C. W. Parmelee		
Membership			Alexander Silverman	R. A. Weaver F. P. Nickerson L. W. Manion	Alan G. Wikoff	Geo. E. Thomas	
Program			E. Ward Tillotson	L. D. Mercer G. T. Stowe Philip Dressler	D. F. Albery	Chas. W. Berry	
Rep. on Comm. on Nominations			E. Ward Tillotson		D. F. Albery		
Executive Committee		A. Foltz C. W. Crane G. H. Brown C. A. Bloomfield R. H. Minton Abel Hansen Chas. H. Cook August Staudt	A. Silverman A. F. Greaves-Walker E. W. Tillotson R. M. Howe H. G. Schurecht	A. S. Walden W. M. Clark	W. W. Wilkins H. E. Davis D. F. Albery A. G. Wikoff		

NOTES AND NEWS

HIGH HONOR FOR E. V. ESKESEN

Knight of Danebrog Conferred on Local Man by King of Denmark

"The decoration of Knight of Danebrog,[1] has been conferred upon Echardt V. Eskesen, president of the New Jersey Terra Cotta Company for his interests in this country in American-Danish activities, and the part he has taken in the interchange of students between Scandinavia and America. The decoration is one of honor; only two or three other Danes in the United States having been so honored by King Christian X.

"Danebrog is the name of the Danish flag. It is more than 1,000 years old; the oldest flag in the world.

"Mr. Eskesen has been prominent among the Danes of America for many years, at one time being president of the Danish-American Society of the United States. For a period of years he was trustee of the American-Scandinavian Foundation, a fund created by Mr. Poulsen of the Hecla Iron Works to aid in the education of students of Danish parents.

"Besides being president of the New Jersey Terra Cotta Company, Mr. Eskesen is also president of the Royal Copenhagen Porcelain and Danish Arts of 21 West 57th Street, New York City, and president of the National Terra Cotta Society, to which honor he was elected at the convention of the terra cotta industry at Atlantic City on April 20. Mr. Eskesen is also a director of the First National Bank this city and Treasurer of the Matawan Tile Co."

E. V. Eskesen.

At the age of twenty-three he was still holding a clerkship in Copenhagen. The political restrictions of the early 'nineties which, to the free spirited made life seem unbearable, may have contributed to some extent to his longing for the American freedom and opportunities, and it may be that the urgings of three brothers and a sister who had previously come to America was quite an influence but we believe it was the demand for exercise of Mr. Eskesen's inborn ability to achieve that constituted the strongest urging for America, the country where all have equal opportunities for full exercise of talents.

Mr. Eskesen has shown that his interests have been much broader than the earning of a livelihood and that they included others than himself and family. He always loved art, literature and music and sought every opportunity for cultural development of self in these lines. This life of the cultural resulted in contacts with men and ideals which gave a loving and lovable direction to his workaday thoughts and deeds.

The *World's Work* obtained from immigrants of different nations their early impressions of America and why they remained here. Mr. Eskesen's statement appeared in the February, 1921, issue. His simple beginnings and his honorable attainments prompt a statement of his formula for a successful life:—Work, study, love with the

[1] *Perth Amboy Evening News*, May 3, 1923.

cultural arts, and an active helping interest in his fellowmen. The following excerpt from the article in the *World's Work* is characteristic of Mr. Eskesen's ideals:

"Outside the gate I found my younger brother waiting for me. He had been working in a terra cotta factory. So after looking around for a couple of days we secured work as pressers in an architectural terra cotta plant located in Long Island City. It was hard and unusual work for me, my surroundings rough, ugly, depressing.

"The first years of an immigrant's life are always the hardest. These years leave their marks and are never forgotten. For the man who has to fight his way up from the bottom, it is work, work, work—hard, grinding work. But it is not this that leaves its mark—it is the fact that he is made to feel that he is an outsider, a Pariah. My early years in American were before the great influx of immigration from South and East Europe. The word "greenhorn" was then very much in use and was applied to any one who was not born here. It carried with it a stigma, and was meant to hurt.

For me, as for other ambitious immigrants, the first years in America were bare of leisure or recreation. After the hard, manual labor of the day, I went to evening schools to study English, bookkeeping, stenography, and many other things which I found necessary in order to advance myself. It was sometimes two schools in one evening. I had to put aside all those things that represent the finer ideals of life, music, art, literature. I had expected that I would have to give up for a time my writing and poetry; but I had not expected to find my life stripped so absolutely bare of even a reference to these things—the talk around the shop and outside was mostly about baseball and prizefights—so different from what I had been accustomed to in Denmark.

"After about four years of manual labor and study, I found in my selected trade the opportunity for success. The idea of making useful and beautiful things out of clay appealed to me as a happy combination of industry and art, of getting perhaps satisfactorily close to art. I took hold of this thing and stuck to it. The old desires of my boyhood, to rove and adventure, came to me, but I repressed them even though I sometimes felt that in doing so I was bridling part of my better self. I did not, like many of my countrymen, Jacob A. Riis for instance, strike out into the uncertain, wandering from place to place, depending on chance jobs between communing with nature. So my experience as an immigrant is commonplace."

CHANGES IN PERSONNEL AND ASSIGNMENTS

BUREAU OF MINES

Dr. Bowles Superintendent, New Ceramic Experiment Station

Dr. Oliver Bowles, mineral technologist of the Bureau of Mines, has been designated by the Secretary of the Interior as superintendent of the new mining experiment station of the Bureau to be established at Rutgers College, New Brunswick, N. J., which will specialize in problems involved in the production and utilization of the various non-metallic minerals. Dr. Bowles will enter upon his new duties July 1.

Dr. Bowles was born in Canada and educated at the University of Toronto, obtaining his degree of B.A. in 1907, and of M.A. in 1908. The degree of Doctor of Philosophy was conferred by George Washington University in 1922. He was engaged in field work for the Ontario Bureau of Mines during 1908–1910, and was instructor in petrography at the University of Michigan in 1908–09. Until 1914 he lectured on rocks and minerals at the University of Minnesota, and made a comprehensive study of Minnesota quarries. The results of this work have been published as *Bulletin*, No. 663

of the U. S. Geological Survey. Since 1914 Dr. Bowles has been stone quarry and non-metallic specialist in the Bureau of Mines, and has written many technical papers and articles. His labors have recently been directed chiefly toward quarrying problems in the lime industry.

The new station will undertake selected problems in mining, treatment of non-ceramic uses of such non-metallic minerals as bauxite, feldspar, Fuller's earth, graphite, gypsum, limestone, mica, phosphate rock, salt, sand and gravel, slate, sulphur, garnet, asbestos, and talc.

Dr. S. C. Lind, Chief Chemist, Bureau of Mines

Dr. Lind, who will assume the position of chief chemist of the Bureau of Mines on July 1, studied at Washington and Lee University, Massachusetts Institute of Technology, the University of Leipzig, the University of Paris, and the Radium Institute of Vienna. In 1912, while acting as assistant professor of chemistry at the University of Michigan, he was appointed physical chemist with the Bureau of Mines. Later he was detailed to take charge of the Bureau's Rare and Precious Metals Experiment Station at Reno, Nevada. His chief work at that station has been on radioactivity, radium extraction and measurements; the influence of radiation on chemical reaction; and the relations of gaseous ionization to chemical action. Dr. Lind is the inventor of the well-known Lind interchangeable electroscope, used in the examination of rare metals and gases.

Courtesy of Harris & Ewing

DR. SAMUEL C. LIND.

Dr. Moore to Enter Firm of Consulting Chemists and Metallurgists

Dr. Richard B. Moore, chief chemist of the Department of the Interior, Bureau of Mines, has resigned his post to take effect June 1. Dr. Moore will enter the commercial field with a well-known firm of consulting chemists and metallurgists in New York City.

Previous to his governmental service, Dr. Moore was closely associated with Sir William Ramsey, the eminent English chemical investigator, in research work on the rare gases. In 1911 he was appointed assistant chief of the division of chemical and physical investigations in the Bureau of Soils, Department of Agriculture. While with the Bureau of Soils, he became much interested in the possibilities of the development of the radio-active ores of southwestern Colorado and eastern Utah, and this led to his transfer in 1912 to the Bureau of Mines and to his being detailed to establish a rare metals experiment station of the bureau in Denver.

Dr. Moore initiated the bureau's program for the production of radium in the United States from the Colorado and Utah ores, which were being shipped to Europe and concentrated there. By the application of processes developed by radium having a market value of nearly one million dollars was produced through a coöperative

agreement between the Department of the Interior and the National Radium Institute. Dr. Moore was largely instrumental in bringing to the attention of American medical men the value of radium in cancer treatment, and in encouraging the use of mesothorium as a substitute for the infinitely more valuable radium in the manufacture of luminous paint. The widest recognition has been accorded Dr. Moore on account of his investigative work on radio-activity and the chemical separation of radio-active types of matter, on the atomic weights of Krypton and xenon, the metallurgy of rare metals, and the liquefaction of gases. Of recent years he has directed the research work of the Bureau of Mines in the practical recovery of helium from natural gas, and it is largely through his work in the Bureau that the cost of this element has reduced from $1,200 per cubic foot to 10 cents, with the promise of further reduction in cost to 3 or 4 cents.

EXHIBITION OF INDUSTRIALLY MADE TABLE WARE

The Arts and Crafts Club, New Orleans

By Mary G. Sheerer

The Arts and Crafts Club of New Orleans, located in one of the oldest houses in the "Vieux Carre," one that has been illustrated many times as typical of the historic French régime, was established to foster a higher appreciation of the arts and crafts of today.

The Club has constantly changing exhibitions of original paintings and crafts, but none of the industrially made wares have been shown. Awakening to the fact that the large mass of people are using the commercial table wares and that more interest should be taken in what most of us use, as well as having a desire to help educate the taste of the public, a small but very interesting display was held of the Onondaga, Sebring, Knowles, Taylor & Knowles, and Lennox Belleek.

The latter, of course, is in a different class, as decalcomanias are not used, but as it is produced in quantity, it was included. The soft, creamy color of the Belleek with its high degree of finish and rich design would lend distinction to any exhibition.

The Onondaga combines a vitrified, well-finished body with variety and snap to the design and color. Obviously the appeal is made to the more educated public. When we remember that only a few years ago we were eating from a plate covered with a realistic landscape, men and women, cupids, fish careening about, fruit, etc., we realize our taste is improving.

The Sebring is to be congratulated on its choice of form, a portion of it grooved, each piece good in proportion and shape. The simple band design at the edge is perhaps the most appropriate to the form, but the Chinese landscape is very attractive in color and spacing, landscape used as design not as a picture. Some of the other designs seem to have been put on without consideration of the form and style of the body.

The Knowles, Taylor and Knowles, a semi-vitreous ware like the Sebring, has a bird and flower arrangement which is Japanese or Chinese in treatment, and which is in very good taste in design and color.

Most of the designs, however, are characterized by neatness rather than freshness and freedom back of which latter are liked by the public as evidenced by the popularity of the best English and Japanese types.

Newcomb College
New Orleans, La.

U. S. STANDARD SIEVE SERIES[1]

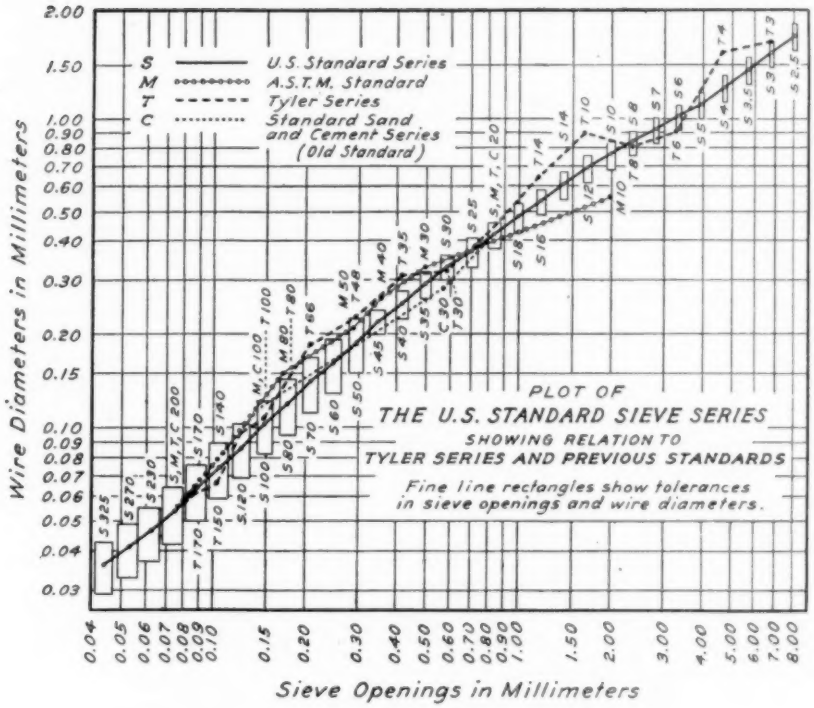

S U.S. Standard Series
M A.S.T.M. Standard
T Tyler Series
C Standard Sand and Cement Series (Old Standard)
PLOT OF
THE U.S. STANDARD SIEVE SERIES
SHOWING RELATION TO
TYLER SERIES AND PREVIOUS STANDARDS
Fine line rectangles show tolerances in sieve openings and wire diameters.
Wire Diameters in Millimeters
Sieve Openings in Millimeters

Table of Fundamental Data

STANDARD SPECIFICATIONS FOR SIEVES

Sieve no.	Sieve opening, millimeters	Sieve opening, inches	Wire diameter, millimeters	Wire diameter, inches	Tolerance in average opening, per cent	Tolerance in wire diameter per cent	Tolerance in maximum opening per cent
2½	8.00	0.315	1.85	0.073	1	5	10
3	6.73	.265	1.65	.065	1	5	10
3½	5.66	.223	1.45	.057	1	5	10
4	4.76	.187	1.27	.050	1	5	10
5	4.00	.157	1.12	.044	1	5	10
6	3.36	.132	1.02	.040	1	5	10
7	2.83	.111	.92	.036	1	5	10
8	2.38	.0937	.84	.0331	2	5	10
10	2.00	.0787	.76	.0299	2	5	10
12	1.68	.0661	.69	.0272	2	5	10
14	1.41	.0555	.61	.0240	2	5	10
16	1.19	.0469	.54	.0213	2	5	10
18	1.00	.0394	.48	.0189	2	5	10
20	.84	.0331	.42	.0165	3	5	25

[1] Bureau of Standards, Washington, D. C.

STANDARD SPECIFICATIONS FOR SIEVES (*continued*)

Sieve no.	Sieve opening, millimeters	Sieve opening, inches	Wire diameter, millimeters	Wire diameter inches	Tolerance in average opening, per cent	Tolerance in wire diameter per cent	Tolerance in maximum opening per cent
25	.71	.0280	.37	.0146	3	5	25
30	.59	.0232	.33	.0130	3	5	25
35	.50	.0197	.29	.0114	3	5	25
40	.42	.0165	.25	.0098	3	5	25
45	.35	.0138	.22	.0087	3	5	25
50	.297	.0117	.188	.0074	4	10	40
60	.250	.0098	.162	.0064	4	10	40
70	.210	.0083	.140	.0055	4	10	40
80	.177	.0070	.119	.0047	4	10	40
100	.149	.0059	.102	.0040	4	10	40
120	.125	.0049	.086	.0034	4	10	40
140	.105	.0041	.074	.0029	5	15	60
170	.088	.0035	.063	.0025	5	15	60
200	.074	.0029	.053	.0021	5	15	60
230	.062	.0024	.046	.0018	5	15	60
270	.053	.0021	.041	.0016	5	15	60
325	.044	.0017	.036	.0014	5	15	60

NOTE: In order to utilize cloth now on the market, it will be permissible, until further notice is given to the contrary, to use wire whose diameter is within a tolerance of 10% for the first three groups and 20% for the last two groups. Until notice is given to the contrary, the allowable tolerances on average openings will be 50% more than those given in the above Table.

WASHINGTON, D. C.

STANDARDIZATION OF CRUCIBLE SIZES

BY C. H. ROHRBACH

The Plumbago Crucible Manufacturers of the United States have recently completed, after more than two years' investigation, planning and experimentation, what is undoubtedly the most important work ever undertaken in that industry, namely, the standardization of crucible sizes on a scientific basis.

Exterior shapes and dimensions were worked out for each size so that they would have a true and uniform relationship to every other size, the basis for capacity being 3 pounds of molten copper per number with an allowance of 10% for working space. It was found that this gave an increased capacity on the larger sizes, but that on the sizes from No. 100 down it gave a smaller crucible than had previously been supplied by most of the crucible manufacturers, and a crucible user who, for example, had been using a No. 50 pot, would have to order a No. 60 in the new size to give him the capacity to which he had been accustomed.

To avoid endless confusion and friction with the trade it was determined to adopt the new standards on the basis that had been developed and step them back to the next lower number covering all sizes below No. 100. The dimensions of a theoretical No. 110 pot were used for the new No. 100 size. Under this plan, practically all of the new sizes come close to the average capacities of the old style pots formerly manufactured, *and the user may continue to purchase the size to which he has been accustomed.*

The "American Standard," as the new sizes are designated, is being received with

genuine appreciation by the trade because of the fact that more than ninety per cent of the crucible output of the country is now being made in these sizes, therefore a crucible user can buy pots from almost any crucible manufacturer and not be compelled to change his tongs to suit each new lot of crucibles that he may want to try out. Needless to say the tong manufacturers welcome the opportunity to standardize on one size of tong for each number of crucible.

The new sizes are as follows:

STANDARD SIZES OF BRASS CRUCIBLES

Number	Height, inches	Top, inches	Bilg , inches	Bottom, inches	Approx. cap. in pounds, water
0	2	1 5/8	1 3/4	1 1/4	
00	2 1/4	2	2	1 1/2	
000	2 5/8	2 1/8	2 1/8	1 5/8	
0000	3	2 5/8	2 5/8	1 3/4	
1	3 5/8	3 1/8	3 3/8	2 3/8	.39
2	4 1/4	3 1/2	3 7/8	2 7/8	.78
3	4 7/8	4	4 1/2	3 1/2	1.17
4	5 1/2	4 1/2	5	3 3/4	1.82
5	6 1/8	4 7/8	5 3/8	4	2.21
6	6 1/2	5 1/4	5 3/4	4 1/4	2.60
8	6 7/8	5 7/8	6 1/8	4 1/2	3.13
10	8 1/16	6 1/16	6 9/16	4 13/16	4.8
12	8 1/2	6 3/8	6 7/8	5 1/16	5.6
14	8 7/8	6 11/16	7 3/16	5 1/4	6.4
16	9 1/4	6 15/16	7 1/2	5 1/2	7.2
18	9 13/16	7 5/16	7 15/16	5 13/16	8.6
20	10 5/16	7 11/16	8 3/8	6 1/8	10
25	10 15/16	8 3/16	8 7/8	6 1/2	12
30	11 1/2	8 5/8	9 5/16	6 13/16	14
35	12	9	9 3/4	7 1/8	16
40	12 1/2	9 3/8	10 1/8	7 7/16	18
45	13 3/16	9 7/8	10 11/16	7 13/16	21
50	13 3/4	10 1/4	11 1/8	8 1/8	24
60	14 7/16	10 13/16	11 11/16	8 9/16	28
70	15 1/16	11 1/4	12 3/16	8 15/16	32
80	15 5/8	11 11/16	12 11/16	9 1/4	36
90	16 3/16	12 1/8	13 1/8	9 9/16	40
100	16 11/16	12 1/2	13 1/2	9 7/8	44
125	17 3/8	13	14 1/16	10 5/16	50
150	18 3/8	13 3/4	14 7/8	10 7/8	60
175	19 1/4	14 3/8	15 9/16	11 3/8	70
200	20	15	16 1/4	11 7/8	80
225	20 3/4	15 1/2	16 13/16	12 5/16	90
250	21 3/8	16	17 5/16	12 11/16	100
275	22	16 7/16	17 13/16	13	110
300	22 1/2	16 7/8	18 1/4	13 3/8	120
400	24 5/16	18 3/16	19 11/16	14 7/16	160

1 lb. water = .96 pints or 27.7 cubic inches.

NOTE: The Plumbago Crucible Association was organized July 15, 1919 and its activities along technical lines have thus far been confined mostly to the standardization of sizes. The officers of the Association are: H. A. Ross, President, Ross-Tacony Crucible Co., Philadelphia, Pa.; D. N. Clark, Vice-President, President, Naugatuck Valley Crucible Co., Shelton, Conn.

PLAN ESTABLISHMENT OF SCHOOL OF CERAMICS AT GEORGIA TECH[1]

Decision Reached at Atlanta Meeting of Georgia Producers of Clay Products Who Form Permanent Organization

A permanent organization of Georgia producers interested in the clay products industries in the state, was perfected at a called meeting held in Atlanta recently, and definite arrangements made for the establishment at the Georgia School of Technology, in Atlanta, of a school in ceramic engineering.

B. Mifflin Hood, president of the B. Mifflin Hood Brick company of Atlanta, was named general chairman of the permanent organization, and J. D. McCartney, of Savannah, Ga. secretary. The motto of the organization is "Educate Georgia Boys to Develop Georgia."

The various companies represented at the meeting donated a large part of the building materials and money that will be required for the construction of the school, among them being $1,500 worth of buliding materials by the B. Mifflin Hood Brick Company; $1,500 worth of laboratory equipment by the Central of Georgia Railroad, and $1,000 worth of equipment by the Atlanta Terra Cotta Company. Other contributions of a similar nature are expected from the affiliated industries throughout the state.

Another state-wide meeting is to be held at the Georgia School on May 29, at which time committees will be appointed for conducting a state-wide campaign for support of the proposed school, which, it is expected will be ready within a year.

Those in charge of the ceramic engineering school estimate that construction of the first unit, including laboratories, class-rooms, and so forth, will cost about $18,000 to $20,000, and that maintenance will be around $8,000 per year. It is proposed to build the school so that other units can be added later on.

The campaign to secure the needed funds is already under way, and Mr. Hood reports that he is meeting with such success that the project now has become an assured fact. He states too, that at a further meeting to be held May 22 in Atlanta the final arrangements and plans for the school are to be discussed, and that it will probably be known at that time just when work will be started.

A PROJECT WORTHY OF SUPPORT

The project to supply to science and industry a publication of physical and chemical constants is making very definite progress. The value of this undertaking cannot be over-emphasized. The missing data are so important, the uncertain data so much, that the effort to critically evaluate data already in existence and to encourage investigations and stimulate researches to provide new data is an undertaking that has immense possibilities to industry and science.

[1] *Evening Review*, East Liverpool, Ohio.

The publication will be known as "International Critical Tables of Numerical Data of Physics, Chemistry and Technology." Proposed by the American delegates at the meeting of the International Union of Pure and Applied Chemistry in London, 1919, this project was approved by the Union and the International Research Council and the responsibility of carrying it out assigned to America.

The editors are at work at the headquarters of the National Research Council, which has organized the project through a Board of Trustees and an Editorial Board. Dr. E. W. Washburn is chairman of the editorial board and editor-in-chief.

In the choice of the data to be secured careful consideration has been given by the editorial board to the needs of industrial and technical men as well as of the more academic research men. Effort has been made to learn the constants that are needed in industry, and arrangements are being made to try to provide these. Much information not hitherto published, but ascertained, will be included. Specialists in both Europe and America have been enlisted.

It is necessary to underwrite this project, the National Research Council not having funds of its own for such a purpose. Industry is, therefore, being asked to provide the support. It is estimated that not less than $200,000 will be needed, and roughly $75,000 has already been raised or subscribed. The Board of Trustees is anxious to secure as soon as possible $125,000 still needed, so that there shall be no unnecessary delay in the publication of what is recognized as one of the most needed and valuable pieces of work for the benefit of science, industry, and the country at large.

RESEARCH FELLOWSHIPS IN CERAMICS

Engineering Experiment Station and U. S. Bureau of Mines at Ohio State University

During the past year two men have done their work for their doctorate at O. S. U. with the Bureau of Mines, Ceramic Experiment Station. Both investigations have been in the field of refractories. The arrangement has been so satisfactory to all parties concerned that three fellowships have been established for the ensuing school year whereby a man may spend his entire time with the Bureau doing the work on a problem agreed upon between the department in the College in which the fellow is doing his major work and the superintendent of the Bureau. The University is operating through the Engineering Experiment Station. The director of this Station has appointed a Committee consisting of the heads of the departments of ceramics, metallurgy and chemistry to choose appropriate problems and to select the incumbents. The fellowships carry a stipend of $750 a year.

CONTEST DATE ADVANCED

The closing date for the contest announced by the Vitreous Enameling Company of Cleveland to secure a *new idea* for an enameled product has been advanced to August 1. Correct information regarding this contest may be found in the advertisements in the June *Journal*, p. 3.

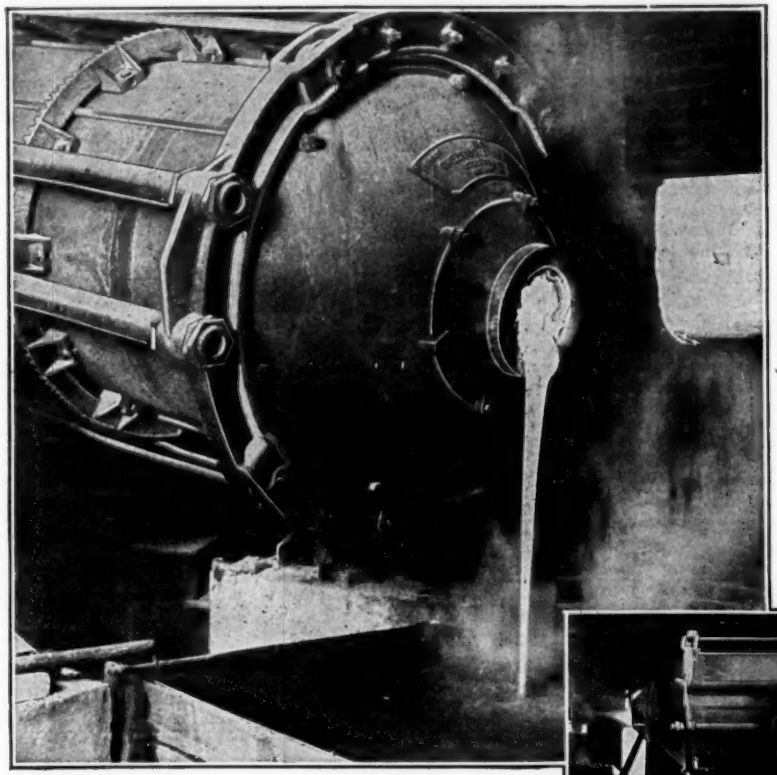
IMPORTANT MEETINGS OF AMERICAN CERAMIC SOCIETY

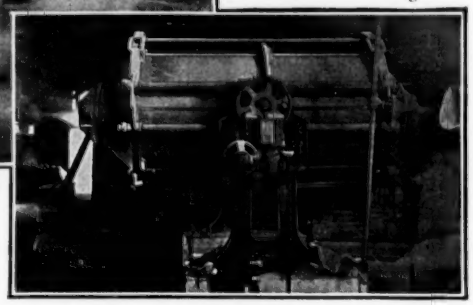
SUMMER MEETING—Toledo, Detroit and vicinity, August 8–9–10 and 11. A wide variety of plants to be visited. Pleasant excursions and entertainments. Detailed program will be mailed later.

FALL MEETING—National Exposition of Chemical Industries, week of September 17, New York City. Wednesday, September 19, is Ceramic day. The SOCIETY plans a profitable technical program.

CALENDAR OF CONVENTIONS

American Ceramic Society (Annual Meeting)—Atlantic City, Feb. 4, 5 and 6, 1924.
American Ceramic Society (Summer Meeting)—Toledo, Detroit and vicinity, August 8, 9, 10 and 11, 1923.
American Chemical Society (Fall Meeting)—Milwaukee, Wis., Sept. 10 to 14, 1923.
American Electrochemical Society (44th Meeting)—Dayton, Ohio, Sept. 27 to 29 (Dates Provisional).
American Electroplaters' Society—Providence, R. I., July 2–5.
American Face Brick Association—First Week in December.
American Face Brick Association (Southern Group)—West Baden, Ind., November.
American Gas Association—Atlantic City, Oct. 15 to 20.
Clay Products Association—Chicago, Ill., Third Tuesday each month.
Fire Underwriters' Association of the Northwest—Chicago, Ill., Oct. 17–18.
National Exposition of Chemical Industries (Ninth)—New York, Sept. 17–22.
Sanitary Potters' Association—Pittsburgh, Pa., Monthly Meetings.
Tile Manufacturers' Credit Association—Beaver Falls, Pa., Quarterly Meetings.





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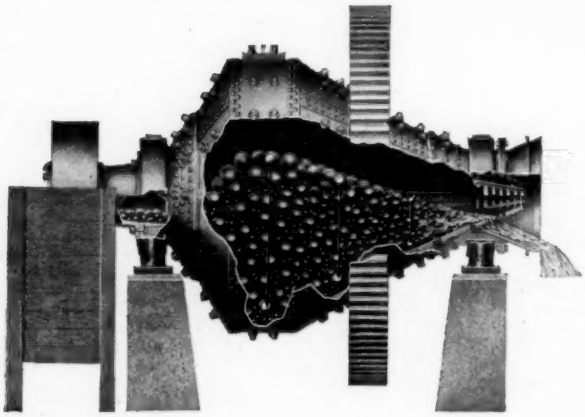

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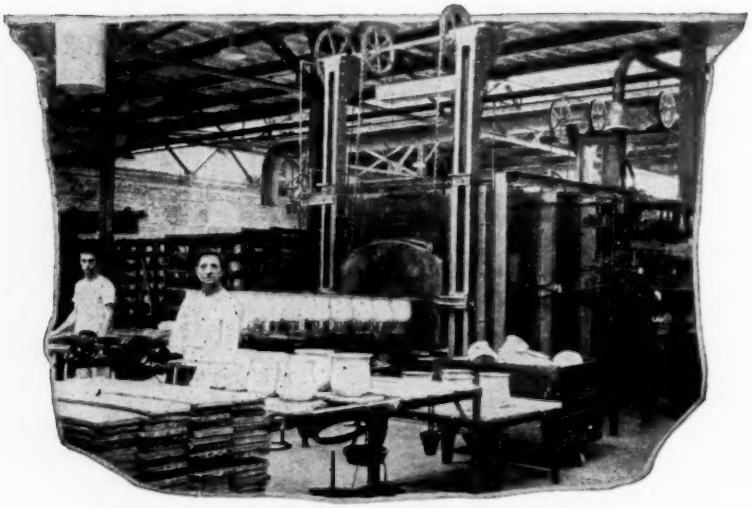

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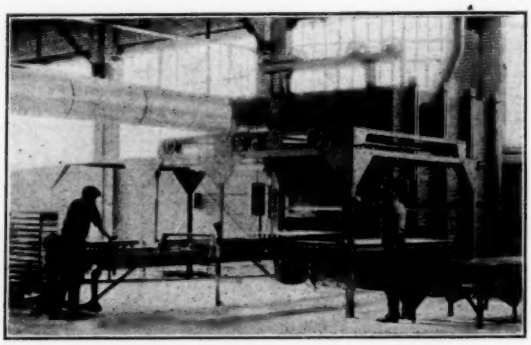

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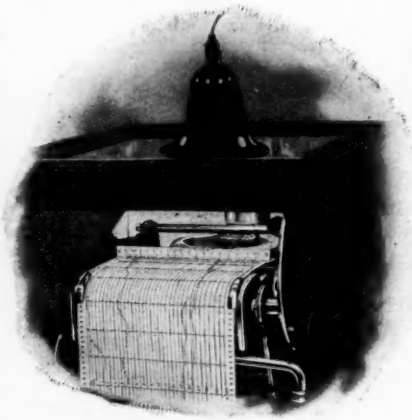

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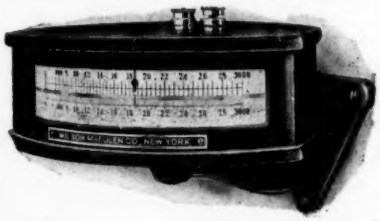

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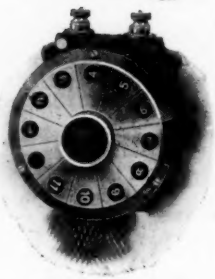

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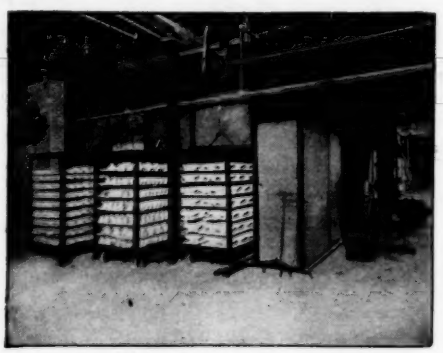

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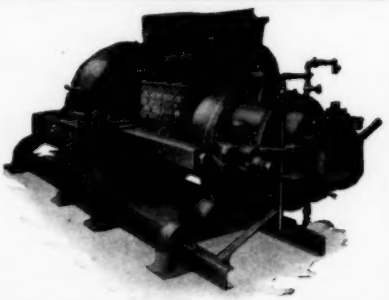

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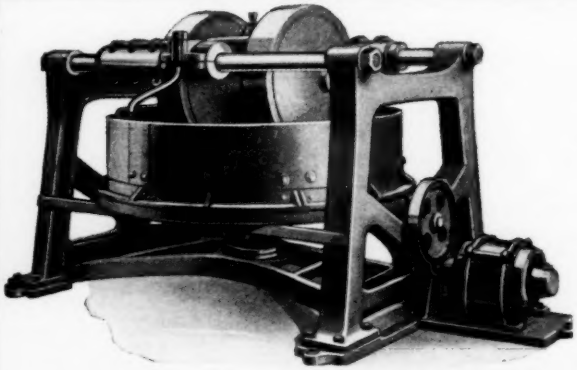

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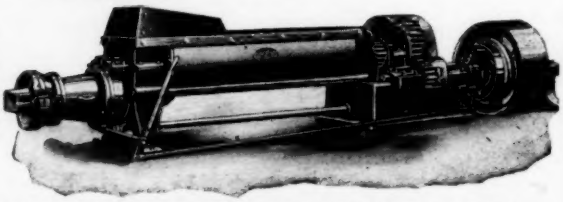

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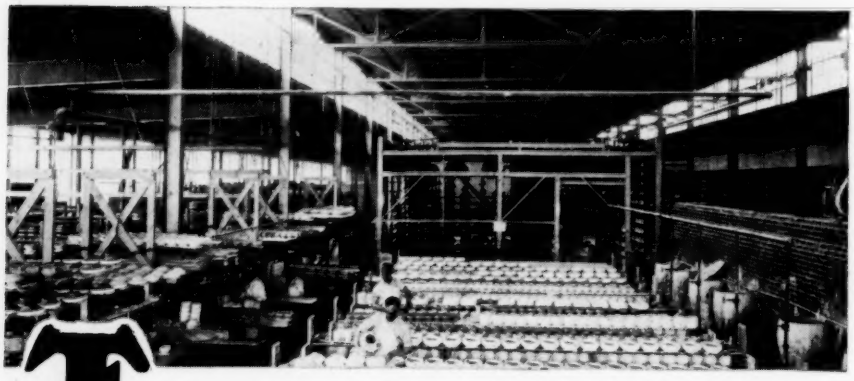

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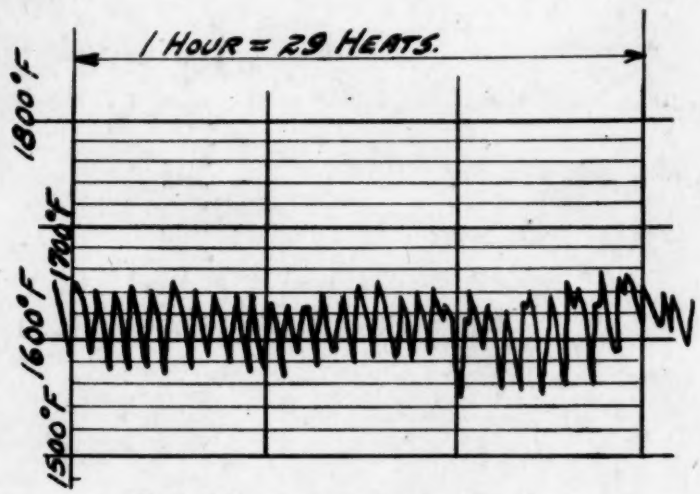

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